Fourth Progress Report 1960-1961

COOPERATIVE SNOW MANAGEMENT RESEARCH

SNOW STUDY AREAS AND SNOW ZONE IN CALIFORNIA, 1961

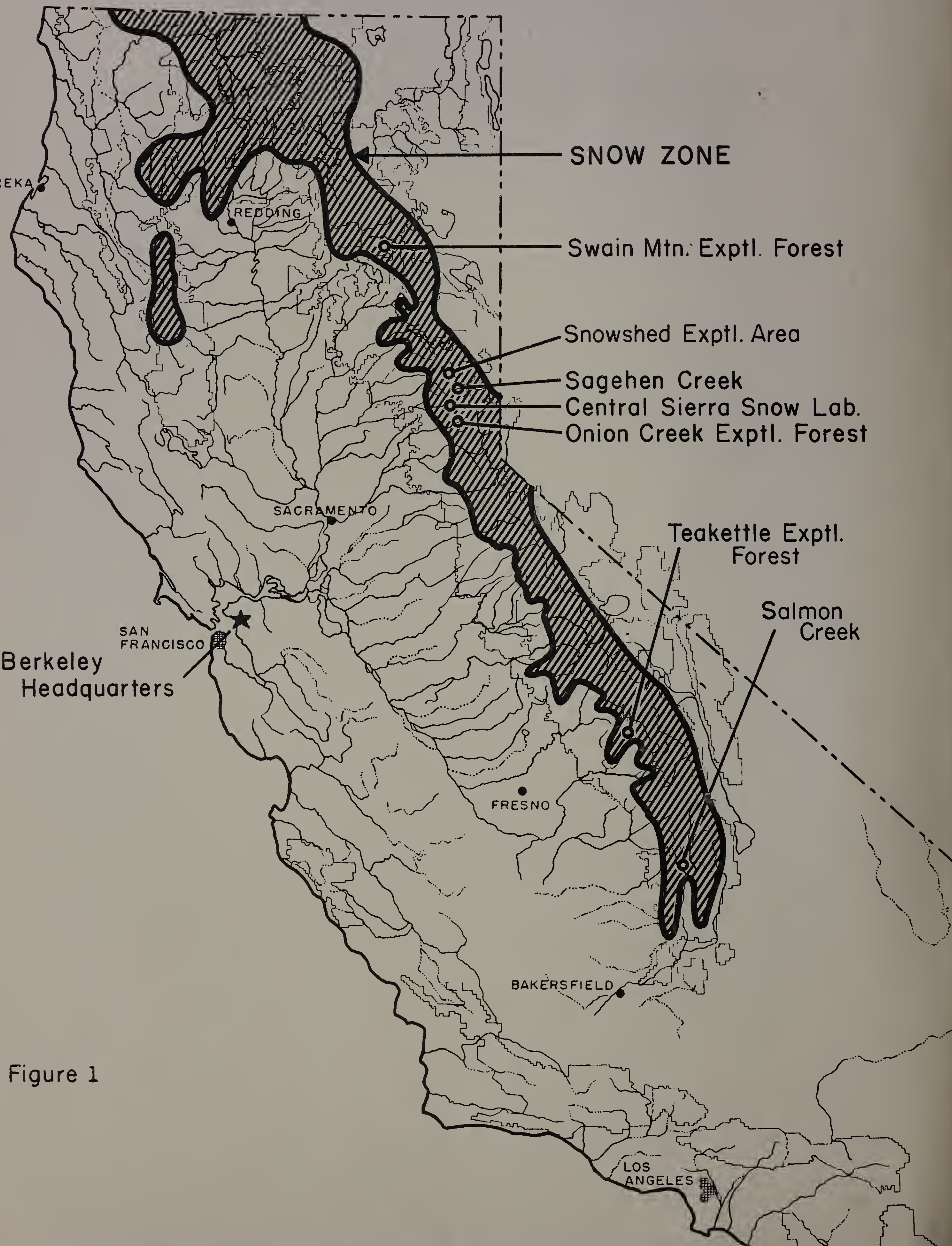

Figure 1

June 30, 1961

FOURTH PROGRESS REPORT, 1960-61

CALIFORNIA COOPERATIVE SNOW MANAGEMENT RESEARCH

by

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with cooperation of

State of California, Department of Water Resources

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1/ Pages 1 through 56 are contained in the 1957-58 Progress Report, pages 57 through 94 in the 1958-59 Progress Report, and pages 94 through 140 in the 1959-60 Progress Report.

SUMMARY

This is the fourth progress report of watershed management research in California's snow zone conducted by the Forest Service since July 1956 in cooperation with the State Department of Water Resources.

Three formal progress reports precede this report: the 1957-58 report (11) describes the problems, objectives, and methods of the first eighteen studies undertaken, and progress for the first two years of the study. The second report (1958-59) (25) and the third report (1959-60) (34) give individual year progress and objectives and methods for new studies.

This report highlights results for the fifth year of Snow Management Research, describes two new studies, and outlines ten new studies proposed for the second five years of the research program.

Eleven technical papers and one summary paper were published during the past year on subjects ranging from "accuracy of precipitation measurements" to "brush removal effect."

Snow was measured at 104 Sierra Nevada snow courses, representing many conditions of natural forest stands, and conditions that simulate alternative methods of managing forests and brushlands for snow accumulation.

Summer soil moisture losses were measured at some five hundred points, representing a wide span of forest sites--different slopes, forest conditions, types of logging, methods of slash disposal, and natural and cleared brushfields.

Streamflow and sediment deposition measurements were continued in ten experimental watersheds; suspended sediment measurements were taken at some thirty-six places, including logged and unlogged watersheds, burned and logged watersheds, unburned watersheds, and watersheds being calibrated for future treatment.

Location maps and detailed descriptions of all study sites are given for the first time in this report.

This was a year of extremely light snowpack, following the moderately light snowpack year of 1960, the light snowpack year of 1959, and the extremely heavy snowpack year of 1958.

Plans for the coming year (July 1961 through June 1962) are to concentrate field work on the new studies: studies of the duration of logging effects on water losses; studies of the effects of emergency physical and vegetative treatment of wildfire areas on flood peaks, sedimentation and soil moisture losses; and plot tests of alternative methods of treating forest and brushlands for improved water yield. Additional field work and laboratory work on soil erodibility is planned to sharpen the already encouraging results of these studies. Continued emphasis will be placed on analyzing the past data thoroughly, keeping analysis of new data as current as possible, and publishing results.

Financing and excellent cooperation in the project have made possible rather satisfactory progress. The State's contribution through the Department of Water Resources for the research was $68,500 this past year. The Forest Service matched this amount and conducted the research. Other agencies continue to lend a hand: Pacific Gas and Electric Company, Fibreboard Inc., the Weather Bureau, the U. S. Geological Survey, the Department of Zoology of the University of California, and the Tahoe, Sierra, and Sequoia National Forests.

Reprints of published papers are available, and other information is available upon request. To make this information more accessible, a detailed index has been included as part of this report. Inasmuch as this is a continuation of previous reports, page numbers start with 141.

FOURTH PROGRESS REPORT, 1960-61

CALIFORNIA COOPERATIVE SNOW MANAGEMENT RESEARCH

by

Henry W. Anderson and Lucille G. Richards

INTRODUCTION

In California's snow zone, research is under way on the hydrology of the zone, and particularly on the effects of land use and land management on the water yield from this important water supplying area. The studies are being made by the Pacific Southwest Forest and Range Experiment Station of the U. S. Forest Service, with the cooperation of the Department of Water Resources of the State of California. Assistance of various kinds has been provided by the University of California, the U. S. Weather Bureau, the U. S. Geological Survey, Fibreboard Inc., and the Pacific Gas and Electric Company.

Snow Management Research aims are to add to the present body of knowledge of the hydrology of the zone so that future land and water managers can make decisions on management for water supply and water control:

1. Suggest methods of land and vegetation management in the snow zone for maintaining or improving water yield or water quality.

2. Test a variety of different management methods which promise desirable effects or threaten adverse effects on water yield or water control.

3. Further our understanding of basic hydrologic processes of how water is supplied, detained, and discharged under the physical conditions that prevail or may be created in snow zone watersheds.

KINDS OF STUDIES

This is a report of progress during 1960-61 in each of seventeen studies now under way and an outline of objectives and methods for two new studies started during the year. The objectives of the first 18 studies, the methods used in each study, and some of the results have been outlined in three previous progress reports (11), (25), (34), and in some 40 other publications. This report will concentrate primarily on results of past studies and future plans. The studies are of four kinds:

1. Inventories of present conditions of:

Water yield	(Study No. 1-10),
Land conditions	(Studies No. 1-1, 1-5),
Soil erodibility	(Study No. 1-18).

2.	Studies of basic meteorology, snow, and heat balance	(Studies No. 1-4, 1-6, 1-7, 1-9, 1-11 in part, 1-13, 1-14, and 1-15).
3.	Development and testing of methods of improving water yield and controlling sediment	(Studies No. 1-8, 1-11 in part, 1-16, 1-19, 1-20, and 1-22).
4.	Pilot tests of various forest and land management methods on experimental watersheds for their effects on streamflow and sedimentation	(Studies No. 1-2, 1-3, 1-12, 1-17, and 1-21).

Detailed plans of these studies, data collected, summaries, and reports are available for inspection upon request.

The study areas are shown in Figure 1 (inside cover). Locations of the individual study sites are shown in Figures 4, 5, and 6; detailed descriptions of the sites are given in Table 9.

INDIVIDUAL STUDIES

Inventory of Sierra Hydrologic Characteristics (Study No. 1-1)

Present forest and other land conditions of the major river basins reaching up into California's snow zone, will limit the possibilities of management of those watersheds for improved water yield. How much of the snow zone area is subject to management for increased water yield? An inventory of the forest and brush cover in the Sierra west-side above 5,000 feet made by Richards (41) gives some indication. Amounts of moderate and dense forest cover and brushlands are summarized by major river basins, arranged in order from north to south:

Drainage Basins	Forested[1,2]	Large Brushfields[2,3]
	Percent	Percent
Feather R.	24	27
Yuba R.	22	39
American R.	21	24
Mokelumne R.	23	17
Stanislaus R.	26	17
Tuolumne R.	16	16
Merced R.	23	16
San Joaquin R.	28	15
Kings R.	26	12
Kern R.	39	9
Kaweah & Tule R.	45	13
Average	25	17

1/ Forests of greater than 40 percent canopy cover.

2/ Sierra west-side above 5,000 feet latitudes 35° 57-1/2' north to 39° 57-1/2' north.

3/ Brushfields more than 132 feet across their narrowest part.

We see that 42 percent of the high elevation Sierra Nevada has vegetative cover which might be subjected to management for improved water yield. Brushlands subject to management are greatest in the northern river basins, forests in the southern basins.

Benefits in terms of increased water yield may result from harvesting of forest timber crops; water benefits in brushland conversions may help pay for such conversion. Further details of the summary of land conditions by river basins are given in the report by Richards (41).

Plans--To summarize the forest and other land conditions on the experimental watersheds now under study: the Onion Creek watersheds, the Teakettle watersheds, and the Donner Ridge Burn study watersheds.

Performance of Onion Creek Experimental Watersheds (Study No. 1-2)

In the headwaters of the American River (Figure 5) streamflow and sedimentation have been measured in five small watersheds for 3 years. Annual discharges in 1960 averaged some 42 percent higher than in 1959. Annual discharges for 1960, together with the maximum discharge of the year, are given below:

Watershed	Drainage Area sq. mi.	Maximum Yearly Discharge cfs/sq.mi.	Annual Flow, 1960 inches
Onion Creek No. 1	0.19	17	20.9
No. 2	0.48	27	25.4
No. 3	0.65	16	23.1
No. 5	0.39	43	27.6
No. 7	0.80	25	21.8

Daily discharge records for the five watersheds for the water year 1959 are published in USGS Water Supply Paper No. 1635. Provisional daily records for all watersheds for the year 1960 are available upon request.

Reservoir sedimentation in the moderately low runoff year of 1960 ranged from 0.010 to 0.027 AF/sq. mi. Again this year suspended sediment was automatically measured at weir No. 3, to obtain an estimate of sediment outflow from the reservoir. Numbers of suspended sediment samples taken in these and other experimental watersheds are given in Table 1 at the end of this report.

Plans--Plans are to continue gaging these streams, measuring sediment inflow and outflow until such time as a moderately high or high discharge is obtained from watersheds 3, 5, and 7.

We plan to continue our arrangement with the USGS for inspecting the records and publishing the results in their regular Water Supply Papers.

Streamgaging and Sediment Measurements at Teakettle Experimental Watersheds, Kings River (Study No. 1-3)

Streamflow and sedimentation were measured at another set of five small watersheds in the southern Sierra (Figure 1). Peak discharges between the watersheds were quite similar to those in previous years. Maximum discharges and annual flow for 1960 are given below:

Watershed	Drainage Area sq. mi.	Maximum Yearly Discharge cfs/sq.mi.	Annual Flow, 1960 inches
Teakettle No. 1	0.77	9	8.1
No. 2A	0.27	4	6.0
No. 2	0.85	3	5.9
No. 3	0.86	4	7.6
No. 7	0.09	6	8.9

Daily discharges for the water year 1959 for all watersheds are published in the USGS Water Supply Paper No. 1635. Provisional daily discharges for the water year 1960 are available upon request.

Sediment deposition for the watersheds was very low in 1960, ranging from zero to .07 AF/sq. mi. Suspended sediment was also measured and is tabulated in Table 1. An automatic suspended sediment sampler was used in one of the watersheds to measure sediment outflow through the weir.

Plans--We plan to continue to gage the watersheds and measure sediment for at least one more year before installing a road system to facilitate logging. Design of the logging road system will be worked out this year.

Cooperation--The Pacific Gas and Electric Company has generously cooperated in servicing these Teakettle gaging stations during the winter months.

Inventory of Forest Conditions at the Central Sierra Snow Laboratory Snow Courses (Study No. 1-4)

This study is complete. Any further studies of the evaluation of forest conditions will be carried on under Study 1-11.

The results of these studies have been published in three papers. (See publications numbers 1, 6, and 14, at the end of this report.)

Soil-Vegetation Surveys of Castle Creek Laboratory Basin (Study No. 1-5)

This study is complete. The results were published in publication number 5, and summarized in publication number 34, pages 122 and 124. Summaries of forest condition data from this study by topographic position are given in publication number 42. (See publications list at the end of this report.)

Basic Meteorological and Snow Measurements, Central Sierra Snow Laboratory (Study No. 1-6)

Basic meteorological and snow studies this year range from routine collection of weather data to critical review of the literature on snow interception and to instrument testing.

Meteorological and snow records have been taken in and near the Central Sierra Snow Laboratory since the program began in July 1956 (Figures 4 and 5). The records taken and the status of data processing are summarized in Table 2, Appendix A. All records have been microfilmed and cardex referenced. Daily records for the CSSL Headquarters for the period July 1, 1960 to June 30, 1961, are given in Figure 2, Appendix B. Daily precipitation for the years 1960 and 1961 are given in Tables 3 and 3a, Appendix A. Monthly summaries are given in Table 4, Appendix A. An integrated expression of the meteorological and snow conditions--the daily streamflow for Castle Creek for the same period--is given in Figure 3, Appendix B.

Interception of falling snow was analyzed by a critical study of the results of 110 investigations. David Miller identified and appraised some 17 processes operating in snow interception, and suggested how research in interception of snow might well proceed (40). The interrelationships of physical, plant physiological, and microclimatological fields of study were explored in another analysis by Miller (43).

Snow density profiles were measured using the radioactive gamma and neutron probes at CSSL. First indications are highly encouraging in the range of snow density of 17 to 45 percent. In this range, the gamma probe as compared with standard SIPRE tubes, shows approximate linear relationship, with a standard error of estimate of about 5 percent density. Use of the neutron probe shows much greater dispersion than the gamma probe results, but neutron tube results may be useful in appraising high density snow, where gamma probe results are not linear. A report on this study is being prepared by Lloyd Gay.

Radiation measurements in forest stands have been made possible by a newly designed "dirt cheap" radiometer, design furnished us by Goodell of the Rocky Mountain Forest and Range Experiment Station. We have calibrated these radiometers against the Beckman-Whitley net allwave and incoming allwave radiometers. For one half hour readings, the correspondence is very good, linear with nearly zero intercept through the range of -0.05 to 0.40 langleys per minute. Standard error of estimate is approximately 0.03 langleys per minute for 30-minute readings. For use in our studies we are currently making a modified version of Goodell's radiometers which we hope will be more suitable for Sierra field use. These modifications include (1) use of plastic tubing to make a water-proof sensor and (2) substitution of a transistor for the relay to increase the reliability of the counting circuit.

In other studies the reliability of precipitation measurements, ranging from hourly measurements in intensity gages to season-long storage and high elevation storage type gages, was explored. Court (36) found as much as 30 percent variation in hourly precipitation in gages located only a few feet apart. In another study (File Report No. 12) Court compared snow storage-gage measurements with snow-course measurements and with aerial determinations of snow cover in the Kings River basin. Indications were that snow storage-gage measurements frequently gave rather poor measure of the total precipitation in the area and that one could not infer the volume of water stored as snow from snow-course measurements alone.

Cooperation--The Weather Bureau has cooperated in these studies by taking wind direction and velocity measurements for us at their Blue Canyon Station, 20 miles west of the laboratory at an elevation of 5,000 feet. We in turn are supplying daily meteorological, snow, and streamflow data to them which are used in the State Flood Forecasting Service. Water and air samples, taken for radioactive determinations for the State Department of Public Health, were discontinued in mid-year at their request.

Plans--We plan to continue the basic meteorological measurements and testing of instruments outlined above.

Wind Effects on Snow Accumulation in the Forest (Study No. 1-7)

This study was essentially inoperative during the year except that wind measurements were taken in connection with other studies. Wind at 18 inches above the surface was found to be inversely correlated with the canopy cover. The correlation coefficient was -0.482. The average wind in an 8-day period ranged from 0.6 mi. per hour under the dense forest canopy to 4 mi. per hour in a large opening.

Plans--We still plan to analyze the relationship of shelter from wind and eddying of wind by forest canopies to snow accumulation and melt in some 90 snow courses measured during the periods 1957-58 through 1960-61.

Cooperation--This study has been strengthened by the cooperation of the Weather Bureau, in servicing and operating our wind-recording instruments at their Blue Canyon site and working up hourly wind records at that site.

Hydrologic Processes and Erosion Measurements (1-8)

Summer soil moisture losses and snow accumulation and melt were measured in a logged area, an unlogged area, in a power line clearing, and in a brushfield (Figure 5). The logging was a commercial diameter-limit cut, in which all trees greater than

18 inches in diameter were removed. Comparisons of snow accumulation and melt of the cut and uncut old-growth red fir forest at an elevation of 7,000 feet for different dates from December, 1960 to May, 1961 are given below:

Treatment	Water Equivalent - Inches: Dec. 22	Jan. 12	Feb. 28	Apr. 5	May 2
Forest cut	12.3	11.8	17.2	20.7	12.3
Forest uncut	8.8	8.4	9.8	12.9	9.0
Difference	+ 3.5	+ 3.4	+ 7.4	+ 7.8	+ 3.3

Again in 1961 as in 1958 through 1960 there was more water left at the time of maximum pack in the cut forest than in the uncut. This year the difference was about 8 inches more; in other years the differences have ranged from 7 to 10 inches. Snowmelt in the cut area was again faster so there were only 3 inches more water in the cut forest later in the spring. If the more rapid melt in the cut forest continued, the last snow would be found in the uncut forest.

To serve as a contrast to the commercial diameter-limit cutting method, two transects were established across a power line clearing. The clearing runs in an east-west direction on a 20 percent north slope, at an elevation of 6,850 feet. The clearing width was 200 feet, or about 2 times the height of the adjacent old-growth red fir trees. Four conditions are compared: (1) a 125-foot wide strip of the forest margin to the south, (2) a part of the strip 100 feet wide, which had been cleared some time ago and now has a young stand of pine reproduction approximately 8 feet tall (35 years old), (3) a contiguous strip cleared 20 years ago which now has no trees, and (4) the old-growth forest on the north margin of the power line clearing. Mean snow water content at four times during the winter of 1961 (average for ten points each), is given below:

Condition	Snow Water - Inches: Jan. 20	Mar. 13	Apr. 11	May 2	June 7
South, Forest	8.0	11.4	11.9	9.5	1.0
South Cut, with saplings	14.6	23.3	25.4	21.2	0
North, Clear Cut	14.0	21.5	19.0	16.0	0
North, Forest	6.2	9.6	8.8	6.7	0

The windward (south)margin of the forest had more snow than the opposite side, 3 inches more at maximum pack. Snow in the cut strip was about 12 inches greater than in the average of the forest adjacent, with the most snow being at the south margin of the strip. The slowest snowmelt was in the forest, and the last water was left in the forest near the south margin.

Snow accumulation and melt during the winter of 1961 at the Onion Creek brush plots (elevation 6,800 feet) are summarized below:

Site	Water Equivalent - Inches					
	Dec. 13	Jan. 9	Feb. 28	Mar. 20	Apr. 9	May 2
Block C, level ridge	10.4	10.0	12.2	13.6	8.8	2.4
Block D, 24% W slope	9.6	6.8	4.3	8.8	1.7	0
Block E, 21% SE slope	8.8	9.0	7.4	12.6	6.6	0
Average	9.6	8.6	8.0	11.7	5.7	0.8

Again this year the west exposure had considerably less snow than either the level area or the southeast exposure. Mid-winter melt occurred on the sloping courses. Spring melt was slowest on the level area, next on the southeast slope, and greatest on the west slope.

Summer water losses in the commercial diameter-limit cutting (cut in 1957) were again compared with those in the uncut forest. Three-year summary of soil-moisture deficit and summer precipitation is:

	1958	1959	1960
	- -	inches	- -
July-October Precipitation (P)	6.0	3.5	1.6
October soil-moisture deficit (SM)--Unlogged	8.4	9.0	10.0
October soil-moisture deficit (SM)--Logged	7.5	8.2	9.4
Difference	0.9	0.8	0.6

Summer precipitation was about 40 percent effective in reducing soil-moisture deficit. For the unlogged forest the relation is: $SM = 10.7/P^{0.137}$ (for $1.5<P<6.1$). The difference in losses between logged and unlogged sites may be partly caused by precipitation differences and partly by root regrowth from 1958 to 1960; the two effects are confounded in these data.

Basic Meteorological and Snow Measurements, Teakettle Experimental Forest (Study No. 1-9)

Again this year, the Pacific Gas and Electric Company made regular weather observations and measurements for us at the station near Wishon Dam. These measurements are proving useful in working up the streamflow measurements at the Teakettle watersheds and will serve to characterize the years of study in these watersheds.

Plans--Meteorological measurements are needed in this area for analysis of streamflow records and other purposes; so continuation of the measurements will be requested of PG&E.

Water Yield (Study No. 1-10)

A study plan was completed outlining the procedure for evaluating the amounts and timing of delivery of water from various topographic and forest conditions of wildland watersheds in the northern part of the state. An exploratory study was made by Court, seeking methods of expressing streamflow and its variability (45). Court studied the relationship of the first and third quartiles of the annual flow and the maximum flow dates in different years and watersheds. He called the number of days between the first and third quartile flow dates, the half-flow interval. The maximum flow date showed much more variability than the half-flow dates in four southern Sierra watersheds, and the half-flow interval was surprisingly similar for the various basins, being in the neighborhood of 40 days. Court says, "This indicates that as much water comes down these streams during a peak 40-day period as flows during the entire rest of the year." For the years with the greater streamflow, more streamflow comes later; for example, years when the streamflow was 100 percent greater than average, the half-flow date was delayed 17 days. Court concludes: "Whether the half-flow date is the best or even a good criteria for use in analysis of streamflow timing can be determined only by further investigation."

Plans--We intend to explore further Court's "half-flow interval" and other means of expressing streamflow from wildland watersheds and to evaluate the effects of watershed characteristics on these expressions.

Heat Equivalent and Snow in Forest Openings and Forest Slopes (Study No. 1-11)

Two more years of snow measurements from 90 to 104 sites (Figures 4 and 5) have been summarized to give the maximum snowpack water for each year for different slopes, forest openings of different sizes, and forests of different densities (Tables 5 and 5a).

The data have been adjusted to give estimated snow water near the maximum pack--April 1, 1960, and near April 1, 1961. The adjustment was accomplished by using a degree-day factor for each course or part of course and extrapolating backward to the day of maximum pack (1). For both 1960 and 1961 the data were adjusted to a common elevation, 7,000 feet, by adding 1.2 inches for each 100 feet that the course was higher than 7,000 feet in elevation. The elevation of each course is given so these adjustments may be eliminated as needed in some analyses. With these adjustments, we feel that the effects of slope, aspect, and forest conditions on snowpack can be directly compared:

Topography	Snow Water, April 1, 1960		
	In Opening	In Surrounding Forest	Average
	- - - - - inches - - - - -		
North Slopes	36.9	27.8	32.4
West Slopes	32.1	29.2	30.6
Level	32.6	28.3	30.4
East Slopes	32.2	24.7	28.4
South Slopes	26.3	22.0	24.2

Openings had from 3 to 9 inches more water than the surrounding forest at the time of maximum pack. In 1960 the difference between north and south slopes was 8.2 inches as compared to 9.2 inches in 1958 and 1959.

The trapping of cold air at the downhill margin of forest openings again appears to be an important mechanism in delaying winter snowmelt. The downhill sides of forest openings always contain more snow than the uphill side of the same opening (20). West (39) made a detailed study of four courses selected because of the expected imperviousness of the lower opening boundary. The opening sizes were all small, from one-half to one times the tree heights across. For three years, 1958, 1959, and 1960 at the time of maximum snowpack accumulation, the lower part of the forest opening had more snow than the upper part of the same opening: North slopes from 3.0 to 4.0 inches more, south slopes from 3.4 to 9.1 inches more, east slopes from 4.8 to 7.0 more, and west slopes from 9.0 to 13.1 more. West examined other possible mechanisms than cold air drainages in effecting these differences, but concluded, "Cold air drainage...seems to have the most effect on snowpack, causing the accumulation to be greatest in the downslope

segments of forest openings." A simple test, using snow courses on slopes of east and west aspect, showed greater "cold air effects" on steeper slopes, those of 30 percent, than on those of 15 percent.

To study further the effect of cold air barriers in snow accumulation and melt, we have started a study of barriers using paper dams to trap cold air. Paper dams from 3 to 12 feet high were installed across the lower edge or on contour at intervals within five forest openings. Only part-year records were obtained this first year; the data have not yet been analyzed.

Plans--To continue the curtailment of the original "natural condition" snow courses, measuring only those needed to serve as controls in special studies such as the logging in Castle Creek, the "paper dam" study, and the power line transect study. We plan to continue the study utilizing paper dams in ways that simulate alternatives of logging slash disposal in forest openings.

Streamflow and Sediment Measurements, Castle and Salmon Creeks (Study No. 1-12)

The daily streamflow hydrograph for Castle Creek for 1960 is shown in Figure 3. This is the last year in which simple evaluation of the effects on streamflow and sediment production of the 1958 logging of the forest can be made. Now a clearing for a freeway across the Castle Creek Basin is under way (Figure 4). Timber types and volumes cut in the 1958 logging were summarized in Table 1 of the Third Progress Report. Analysis of those data indicated about 1.75 inches increased water yield from the entire basin, or the equivalent of 7.0 inches increase in the logging area.

Water yielded as streamflow was apparently increased a like amount the second year after logging--an indicated 1.8 inches increase, or about 400 acre-feet. This estimate of the increase was obtained by three-way correlation between Sagehen, the South Fork of the Yuba, and Castle Creek basin. (Simple correction could not be made with the South Yuba, for that watershed had a "freeway clearing" in 1960.)

Suspended sediment discharge again decreased this third (1961) season. Because no high flows occurred in this very low runoff year, no attempt was made to calculate the average sediment production under average streamflow conditions; however, sediment concentration for similar streamflow classes can be compared:

Suspended Sediment Concentration for Streamflow Discharge Classes

	15-54 cfs ppm	55-79 cfs ppm
Before logging 1957-58	5	20
1st year after logging 1958-59	10	190
2nd year after logging 1959-60	15	90
3rd year after logging 1960-61	10	45

The rate at which the concentration of sediment is decreasing in the higher discharge classes appears significant; note that the second and third year after logging in each case the sediment concentration in that class was about 1/2 of the previous year's concentration.

Salmon Creek Watersheds, Kern River Basin

To evaluate the effects of logging on sediment and streamflow in the southern Sierra, we are analyzing two study watersheds established in small tributaries of Salmon Creek last year; a third watershed is being established this summer. Each watershed has a small cutoff dam and a 120° weir, similar to those at Onion Creek (Study 1-2). In this study we are collaborating with the Sequoia National Forest, which installed the weirs.

Plans--We will continue to analyze the snow, soil moisture, streamflow, and sediment concentration in Castle Creek watershed during and following the establishment of the freeway across the basin. Three snow courses transecting the freeway area were established previously and two whole years and one part year of pre-construction measurements have been taken. We plan to continue these measurements.

Winter Evapotranspiration in Relation to Forest and Terrain Characteristics (Study No. 1-13)

The only new measurements of snow evaporation taken this winter were in connection with the heat equivalent study--including the study of paper barrier effects (Study 1-11). West has summarized his results for the 3 years study of snow evaporation, and computed the total snow evaporation from the Castle Creek basin

on an average annual basis (42). The 3 years of snow evaporation measurements taken by the PG&E Co. near Wishon Dam have also been summarized. Monthly snow evaporation for the years 1958 through 1960 are given for forest and openings in forests in two areas: (1) the Central Sierra (Table 6), and (2) the southern Sierra (Table 7).

Plans--The snow evaporation part of this study is essentially completed. What can be done about measuring interception losses and evapotranspiration during winter--those problems are next.

Heat Balance Components in Forest and Openings (Study No. 1-14)

Progress has been made in the collection of data, and programming of computer analysis of the elements of the heat balance in the forest openings at the CSSL Headquarters. Measurements of wind, temperature, and humidity gradients and the various components of radiation have been taken. The instruments have been revised so that the information punched on the tape is analyzable with the IBM computers rather than the Bendix-type computers. The program for analysis of the data has been written and analysis is in process.

Plans--We plan to complete the portable instrument, then take periodic sample measurements of the heat components in a variety of forest conditions near the CSSL Headquarters.

Evaluation of Summer Evapotranspiration in Relation to Forest Sites (Study No. 1-15)

In summer the depletion of soil moisture from forest, shrub, and bare sites (Figure 4), has been shown by Knoerr (File Report No. 9) to be related to the saturation vapor pressure deficit (VPD) and the day-length (DL). When soil moisture depletion in the years 1958 and 1959 was plotted against the accumulation of this index (VPD x DL), a single rate coefficient was found to fit the exponential curves for both years of the study. Knoerr also found that there appeared to be a linear relationship between the rate of evapotranspiration from forest sites and the level of soil moisture (46). At red fir forest and Lytton soil series sites, Knoerr reported, summer soil moisture deficits established in the period June to November, 1959, were as follows: 2 inches per foot for the top 5 feet, 1.7 inches per foot for the 6- and 7-foot, and 1.1 inches per foot for the 8- and 9-foot soil depths.

By using the soil moisture deficits obtained by Knoerr, the summer rainfall loss, and the distribution of soil depths obtained from some 535 sampling points in the Central Sierra, we may estimate the average soil depths, summer deficits, and total summer losses (Table 8). Average soil depth was 43 inches (average for the Swain Mountain, Yuba Pass, Sagehen Creek, Castle Creek, and Onion Creek study areas). Summer soil moisture deficit at the end of September,

1959, averaged 6.6 inches; October to November, 1959 losses averaged an additional 0.4 inches; and total summer water loss, including 3 inches of summer rainfall, averaged 10.0 inches. These data apply to forest, brush, and herbaceous sites generally, and take no account of the some 27 percent of bare ground and rock in the area (Paper No. 26 Table 1, and Paper No. 34 Table 3).

Plans--This study is essentially completed, except for reporting the results. Some of the study sites which were measured in the years 1958 through 1960 will be utilized in the study of evaporation suppression (Study 1-22). Other studies in summer soil moisture losses will be carried out under Study 1-19.

Swain Mountain Snow and Soil Moisture Studies (Study No. 1-16)

Snow accumulation and melt data from a strip cut in the forest, under three systems of logging slash disposal, and from adjacent non-cut forest (Paper No. 22 Figure 2) have been summarized.

Snow course measurement dates in the years 1958 through 1961 were selected such that the amount of snow in the "control courses" was approximately equal. Snow water in the old-growth red fir forest on both sides of the 5-chain wide strip was compared with the snow in the cut strip (slash had been removed by dozing and burning). Before cutting the strip, the snow in that area was about 1 inch less than in the other part of the forest; after cutting the strip, snow in the cut strip was from 8 to 15 inches greater than the snow in the adjacent forest. For this strip, cut in a southeast-northwest direction, the snow in the southwest margin of the forest was from about 1-1/2 to 6 inches greater than in the northeast margin.

Snow Course	Average Snow Water--Inches			
	Feb. 6, '58	Apr. 2, '59	Mar. 7, '60	Mar. 31, '61
SW Forest Margin (4 points)	14.4	13.4	17.0	14.5
Cut Strip (7 points)	1/ 13.9	22.0	24.0	28.6
NW Forest Margin (4 points)	16.0	7.0	15.2	13.0
Control 2/ (15 points)	20.0	16.3	20.8	20.3

1/ Before cutting.

2/ Average of two untreated snow courses on opposite sides of treated area (Courses No. 2 and D).

Other differences in snow accumulation were related to how the slash in the cut openings was treated. At the time of maximum snowpack in 1960 and 1961, the differences between the different slash treatments ranged from about 1 to 5 inches, the area in which slash had been piled and burned having the most snow. Differences in snow water left late in the spring were as much as 5 inches; again the piled and burned area had the most snow. The data on snow at maximum accumulation and late season snow are given below:

Logging Slash Treatment	Average Snow Water Equivalent--Inches			
	Mar. 7, '60	Apr. 29, '60	Mar. 31, '61	May 1, '61
Piled and burned	24.0	13.2	28.6	21.0
Lopped to 18 inches	-	11.4	25.8	16.2
Left as it fell	19.0	8.5	27.9	-

Examination of the mass of data indicates that the different treatments of slash had their effect only in early winter and in late spring when snowpacks were shallow. For example, in 1961, March accumulation was identical in all three treatments--8.3 inches of water. However, the large differences in 1960 developed early in the year apparently because of the low snowfall as compared with 1961--about 3 to 4 inches in the opening on January 5, 1960, as contrasted with 10 to 15 inches in the opening on January 4, 1961. We would conclude that during those periods when snow cover on the ground is shallow, slash on the ground accelerates melt.

Plans--We will discontinue snow measurements at Swain Mountain until such time as other forest cutting or similar treatments are installed there or until natural changes occur at the sites. Measurements of slash treatment effects will be taken up in more detail at the Yuba Pass study area. Soil moisture measurements at Swain Mountain will be continued, particularly at the margins of the cut strips to determine the time taken for roots to penetrate the cut areas; these will be made as part of Study 1-19.

Sagehen Cooperative Study of Streamflow, Sedimentation, and Fish Habitat (Study No. 1-17)

Part of the studies in this area are of the effects on snow accumulation and soil moisture of conversion of brushfields to pine. On a 12 percent south slope, at elevation 6,900 feet (Figure 6), the original brush and the surface soil has been dozed into windrows about 80 feet apart on the contour. Detailed measurements of snow accumulation at the margins of the dozed brushfield, at the windrowed piles of earth approximately 3-1/2 feet high, and between the windrows have been made this year.

In this very light snowfall year we found 1 to 6 inches less snow on the windward margin of each of the dozed earth windrows than on the untreated brush area. In small areas on the lee side of the dozed earth windrows, excesses of snow ranged from 8-1/2 to 10-1/2 inches of water. Average snow water content in 100-foot reaches of the windward (south) margin of the dozed brushfield, at the center of the 560-foot wide field, and at the leeward (north) margin of the field are shown below together with the average snow water content in adjacent untreated brushfields:

	Snow Water March 14, 1961	
	Average Inches	Range Inches
Windward (south) Margin	6.0	4.5 - 9.5
Center	3.4	0.5 - 8.5
Leeward (north) Margin	4.1	0 - 10.5
Adjacent Brushfield	6.2	1.0 - 10.5

In this year of light snowfall, snow accumulation in the brushfield appeared to start earlier, reach greater maximum amounts, and persist somewhat longer in the natural brushfields than in the dozed area.

Eighty-three measurements of suspended sediment concentration have been made in Sagehen Creek watershed (10.9 square miles) since October 21, 1957; 30 were taken this year. Because the Donner Ridge fire burned part of the Sagehen area above this site, several new stations upstream of the burn have been established. Measurements at these sites as well as at the downstream site, will be made this year. (Study Plan No. 1-21 gives more details.)

Plans--Continue present measurements of snow and suspended sediment; utilize the soil moisture sites in tests of hexadecanol. (Study Plan No. 1-22 gives details.)

Erodibility of California Wildland Soils, Relation to Sedimentation (Study No. 1-18)

In our study of sediment sources and sedimentation causes in northern California, some quantitative relationships between soil erodibility and soil forming variables have been found (38) (44). The general model that we are examining is: sediment production = f (meteorological causes, terrain and land use modifiers, and inherent erodibility of the soil). The specific model of soil erodibility is: soil erodibility = f (geologic rock type, vegetation cover type, elevation, and geographic zone). We used 8 geologic types, 3 vegetation types, 4 elevations, 3 zones and the interactions of geology

times zone and geology times vegetation; in all, 67 constants were fitted by regression analysis. Geologic type was significant at the 0.5 percent level, vegetation at the 5 percent, and the geology times zone and geology times vegetation at the 10 percent level. The relative soil erodibility associated with soils developed on the various geologic rock types is shown below (considering the surface-aggregation ratio (S/A) as the index of erodibility and assigning acid igneous rock an erodibility of 1.00):

Rock Type	Relative Soil Erodibility
Acid Igneous	1.00
Alluvium	0.95
Schist	0.83
Soft Sediments	0.57
Hard Sediments	0.50
Basic Igneous	0.43
Other Metamorphics	0.40
Serpentine	0.35

These relative erodibilities agree quite closely with those found for the same rock types in western Oregon.

Will improvement in the estimation of surface-aggregation ratio be obtained by analysis of chemical characteristics of the soil colloids? In a study by Wallis and Stevan (38), the amount of calcium and magnesium absorbed on the clays was found related to the surface-aggregation ratio.

Would a combination of chemical characteristics and soil forming factors give even better prediction of erodibility? For a selected sample of 20 soils we tested the combination: (1) surface-aggregation ratio (s/a) as computed from the soil forming factors (44), and (2) the calcium plus magnesium (Ca + Mg), expressed as milliequivalents per hundred grams of soil. We obtained this prediction equation:

$$S/A = 156.4 + 1.06\,(s/a) - 17.11 \times (Ca + Mg) + 0.4 \times (Ca + Mg^2).$$

The t's were all significant. The addition of the soil forming factors of geology, vegetation type, elevation, and zone improved the explained variance obtained by Wallis and Stevan (38) by 30 percent (from 0.48 to 0.63).

Plans--We are continuing this study by taking additional soil samples under refined definitions of the geologic types, breaking the acid igneous rocks down into granite, granodiorite, etc. We will study the relationship of soil erodibility to the minerals and chemical constituents of the parent rock. We plan to continue

assembling the basic streamflow, topographic, and vegetation conditions on the some 60 watersheds for which we have suspended sediment measurements; later we will relate these characteristics of the watersheds and the soils to the measured sediment discharges from the watersheds.

Summer Water Losses as Related to Time Following Logging and Associated Vegetation Recovery (Study No. 1-19)

In this study started in July, 1960, the time since logging is being studied as a factor in determining the summer water losses. Seven new sites have been selected which range in time since logging from 1 year to 12 years (Figure 5). Soil moisture samples have been taken at points starting within the unlogged area and transecting the logged area. According to Ziemer, who is conducting this study, the summer water losses associated with the remaining trees extended only about 1/8 the tree height into the cut area the first year after the cut. The roots of the trees at the margin of the opening gradually reach into the opening, their effect eventually reaching a distance equal to 1/4 to 1/2 the height of the trees.

Plans--This study will be continued for at least one year more, to attempt to sample a year quite different than this extremely dry year just encountered.

Yuba Pass Tests of Logging and Slash Treatment Effects (Study No. 1-20)

As part of this practical-sized test of logging and slash treatment methods, strips have been laid out on the ground and the trees marked and scaled. (Net scale, with 15 percent defect, was 56,000 fbm/Ac in the red fir forest.) Tentative assignment of the 8 alternative treatments have been made to the areas.

Pre-treatment measurements of snow accumulation, soil moisture, and sediment delivery have been made in the area. To evaluate snow accumulation and melt, two transects 1,100 feet long were established. They cross the areas to be cut and extend 300 to 550 feet into both sides of the adjacent forest. (The transects are located at elevation 6,500 feet, in Section 14, T20N, R13E, MDM.) Snow measurements during the winter of 1961 have been taken at a total of 49 points in these transects. Average snow water in the forest at the time of maximum pack (April 11, 1961) was 11.5 inches, with standard deviation of about 24 percent.

Soil moisture measurements were taken in the fall of 1960 and again starting in the spring of 1961 at 33 measurement points distributed along the above two transects. Soils in the area range from 2-1/2 to 12-foot depth, the median depth being 5 feet. Soil moisture content at the end of last year's very dry season was

as little as 9 percent by volume to depths of 11 feet and as much as 29 percent by volume to these same depths. Spring soil moisture at these same sites was from 15 to 19 percent at one site and 38 to 41 percent at the other. These differences indicate considerable differences in the soils in the area.

Suspended sediment measurements have been taken on 8 tributaries of the stream which drains this study area. In general, sediment has been very low in this pre-treatment condition.

Plans--The start of logging will depend on the decision of the Tahoe National Forest with regard to the need for timber in the area. We plan to lay out the detailed slash treatments on the ground prior to logging. If logging is deferred we will take another season's pre-treatment measurements of snow and soil moisture at representative points.

An Evaluation of Forest Fire, Salvage Logging, and Watershed Treatment on Floods and Sedimentation, Snow Accumulation, and Soil Moisture Losses (Study No. 1-21)

This is a new study started in October, 1960. The study area is the Donner Ridge burn of August 20, 1960, which occupies some 39,000 acres in the headwaters of the Truckee River basin. This study extends our evaluations of current land management practices to include the effects of high-elevation fires and emergency rehabilitation treatments on flood, sediment, snow accumulation and melt, water losses, and surface and groundwater quality.

Scope--The study is intended to discover large differences in the effects of burning and of several burned-area management practices upon floods and sedimentation, etc. It is not intended to explore all possible management methods for the most effective flood and sediment control.

Methods--Small watersheds, transects, and plots have been installed as appropriate to particular parts of the study (Figure 6).

Eighteen small watersheds ranging in size from about 80 to 1,100 acres have been selected for study in the Sagehen and Prosser Creek drainages. These represent triplicate evaluations of areas (1) salvage logged, (2) contour terraced, (3) grass seeded, (4) burned with pole-size trees windrowed on contour, (5) burned but otherwise untreated, and (6) unburned. In these 18 small watersheds crest gages have been installed and automatic suspended sediment samplers set in. Surface water quality will be sampled by both automatic sediment samplers and hand samples taken periodically.

Groundwater quality will be sampled in wells near the mouth of each watershed.

Twelve snow courses have been established representing duplicate samples of the treatments listed above. These snow courses generally consist of 10 points each. In treatment No. 2, additional samples are being taken on and near the contour terraces.

Sourses of erosion will be measured by the use of erosion indicators and erosion transects. Duplicate samples of each treatment will be taken.

Although the first year after this fire was one of very light precipitation and snowfall, a few snow measurements have been taken. One hundred suspended sediment samples were taken this first year after the burn. These data have not yet been completely analyzed.

Plans--We tentatively plan to continue this study for about 5 years or until such time as the trends in treatment and recovery can be detected.

Cooperation--This is truly a cooperative project: The Tahoe National Forest is collaborating by conducting all the treatments on the watersheds. Fibreboard Inc. is cooperating by making requested treatments on their lands and in other ways. The USGS is cooperating by analyzing the water quality samples. The University of California, Department of Zoology, is cooperating by continuing the sediment measurements in Sagehen (one of the control unburned watersheds) and furnishing the basic meteorological records from their Sagehen Headquarters.

Evaluation of Hexadecanol as an Evapotranspiration Retardant (Study No. 1-22)

This is another new study started late this year. Part of our second 5-year plan (see study 4 under next major heading in this report) is to evaluate the effects of transpiration retardants in saving water from natural and treated land areas and vegetation types. This study proposes to evaluate the effectiveness of hexadecanol as an evapotranspiration retardant.

Objectives--The objectives are: (1) to make some preliminary tests to determine whether the application of the retardant hexadecanol to the soil will reduce the soil-moisture deficits in natural stands, in cutover stands, in natural brushfields, in brushfields being converted to trees, in soils under herbaceous cover, and in bare soils; (2) to test differences in the retardation result with different amounts of hexadecanol added to the soil; and, (3) to test the effectiveness of simple methods of application of hexadecanol, such as adding hexadecanol to shallow snow surfaces and adding hexadecanol to the natural soil surface plus flushing with water.

Methods--The primary method is rather simple: Add hexadecanol to already calibrated soil-moisture sites under different vegetation conditions (Figures 4 and 6). Measure the soil moisture losses resulting in treated and untreated areas. And compare the differences in water losses between the treated areas and untreated areas in the same years and between predicted water losses from relations established for the same sites in calibration years.

In the Castle Creek and Sagehen Creek area, hexadecanol is being applied at three rates--25, 100, and 500 pounds per acre. Hexadecanol is in the form of an emulsion--10 percent hexadecanol, 1 percent emulsifier, and 89 percent water. After the hexadecanol is applied on the soil, it is washed in with the equivalent of about 1 inch of water. (Incidentally, we have encountered difficulties in getting penetration of water even on forest sites where hexadecanol emulsion was applied at the high rate, 500 lbs./Ac.)

Treatment evaluation will be made with a simple factorial and covariance analysis comparing results of treatment amounts and vegetation types treated.

Plans--We plan to continue this phase of the study for 2 years, evaluating the effectiveness as we go and then deciding whether to continue the study. We hope to extend the study to include applications of hexadecanol in various ways and forms, and tracing of hexadecanol into the soil in plant systems.

Cooperation--The Proctor and Gamble Company is cooperating by furnishing the hexadecanol for these tests; the Tahoe National Forest is collaborating by furnishing available spray equipment and contracting with cooperators for the use of other equipment.

SECOND FIVE-YEAR PLAN

A plan for the second 5 years of research under the California Cooperative Snow Management Research Program was prepared[1], and reviewed within the Station and by the State Department of Water Resources.

The plan briefly outlined the accomplishments during the first 4 years of the study, assessed the compliance with the original plan, acknowledged the cooperation received from various public and private agencies and discussed 10 new types of studies needed to round out the Snow Management Research Program. The new studies are:

1. Inventory of forest conditions on the east-side of the Sierra.

2. Relate floods and sediment sources to meteorology, topography, geology, soil moisture, and land use and condition--east-side and west-side Sierra Nevada.

3. Develop and test methods of restoration of vegetation in the snow zone.

4. Develop and test methods of chemical and biological control of water use.

5. Test riparian and meadow treatment for increased water yield.

6. Develop criteria for road design and methods of control of sediment production from mountain roads.

7. Study alpine snow management.

8. Test post logging treatments for water quality and sediment control.

9. Plot test management effects in Cascade and Klamath Mountain snow zones.

10. Plot test management effects on Sierra east-side conditions.

1/ "Proposed plan for second five years of California cooperative snow management research," by Henry W. Anderson. Pacific Southwest Forest and Range Experiment Station, Berkeley, California, 7 pp., July 1, 1960 (proc.).

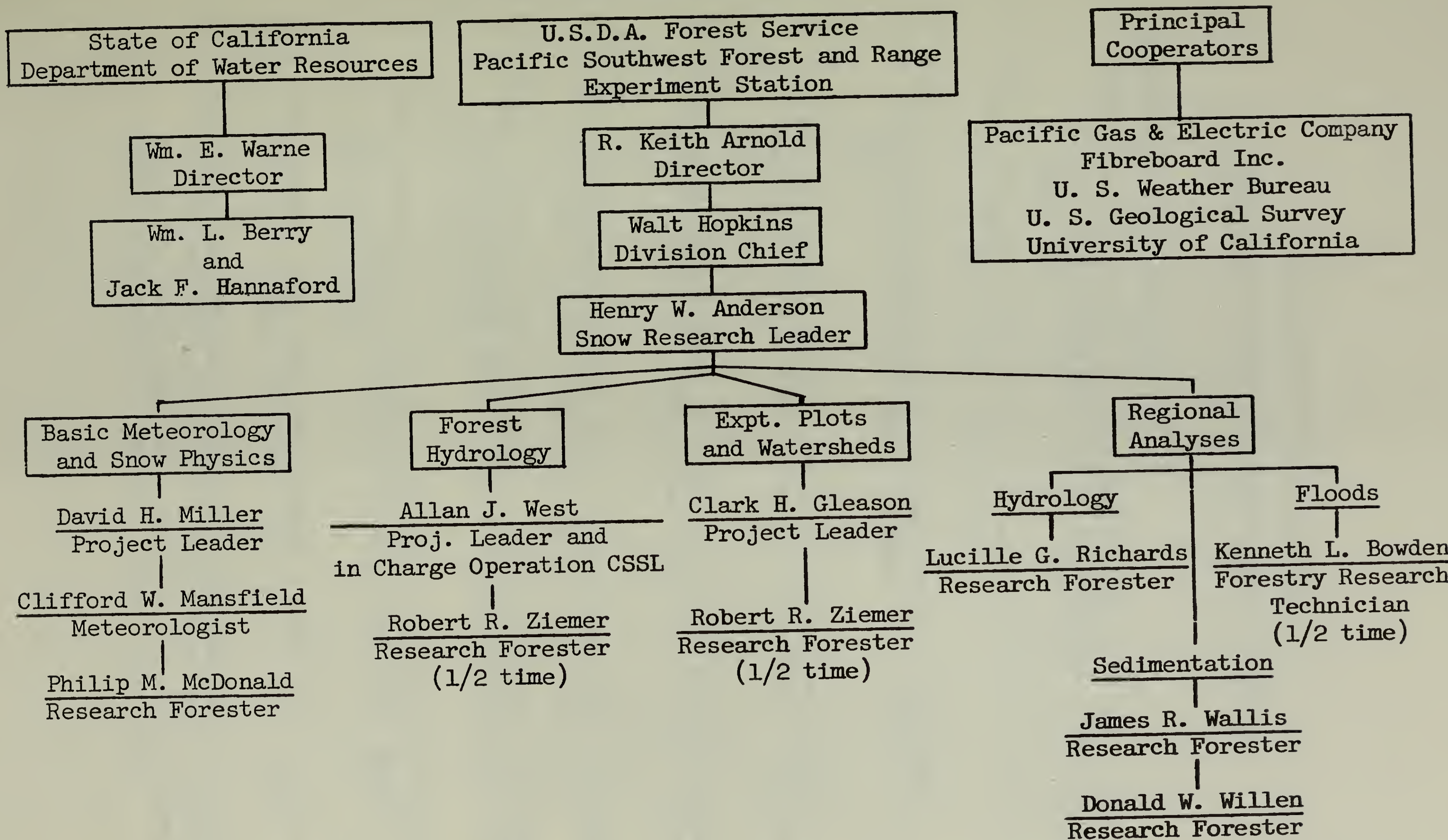
It was further proposed that the studies started in the first 5 years of this program be given priority to the end that completion of the data collection, analysis, and publication of the results be largely accomplished by June 30, 1963.

ORGANIZATION

The organization of the California Cooperative Snow Management Research Program is shown on the next page. In all, eleven professional technicians are working directly on the project, two of them half time. About an equal number of forestry aids and other field and office assistants help keep the project running.

ORGANIZATION CHART - CALIFORNIA COOPERATIVE

SNOW MANAGEMENT RESEARCH 1961-62



Forestry Aids: Franklin Adams, Robert Briggs
Douglas Hauge, Dale Thornton

Clerical Staff: Constance Keller
Adrienne Giles
Carmen Means

Statistical Clerk: Marion Hart

Special Services: C. M. Walker, Editor: Wm. O'Regan, Statistician
R. M. Miller & Sharon Roof, Data Processing

Admin. Services: F. W. Bacon, Chief, Divn. Station Management

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APPENDICES

A. TABLES

B. FIGURES

C. REPRINTS, selected 1960-61 publications

APPENDIX A

TABLES 1-9

Table 1.--Suspended sediment sampling in experimental watersheds

Name		Major River Basin	Drainage Area	Date of First Sample	No of Samples
			Sq. mi.		
Teakettle	No. 1	N. Fk. Kings	0.77	5-30-58	2
	No. 2a	N. Fk. Kings	0.27	5-29-58	2
	No. 2	N. Fk. Kings	0.85	5-29-58	2
	No. 3	N. Fk. Kings	1/ 0.86	5-29-58	84
	No. 7	N. Fk. Kings	1/ 0.091	-	0
Onion Creek	No. 1	N. Fk. American	0.19	5-24-58	22
	No. 2	N. Fk. American	0.48	5-24-58	24
	No. 3	N. Fk. American	0.65	5-24-58	83
	No. 5	N. Fk. American	0.39	5-23-58	24
	No. 7	N. Fk. American	0.80	9-19-58	19
Castle Creek	No. 1	So. Fk. Yuba	3.96	5-18-57	2/ 601
Sagehen Cr.	No. 1	Truckee	10.9	10-21-57	83
Donner Ridge Watersheds		Truckee	-	10-6-60	100
Yuba Pass Watersheds		Truckee	-	6-9-60	12

1/ Revised October, 1960.

2/ 452 samples taken at gaging station; 149 samples taken elsewhere in basin.

Table 2.--Meteorological, snow, and soil moisture records taken and status of data processing

STATION	ELEMENT	INSTRUMENT	FREQUENCY OF READINGS	PERIOD COVERED FROM	PERIOD COVERED TO	PROCESSING STATUS
H Headquarters, CSSL	Precipitation	Recording gage	Continuous	12-4-56	6-30-61	Hourly tabulations made; published by U.S. Weather Bureau in "Hourly Precipitation Data."
	Snowfall	Snow Board	Daily, Winter season	10-31-56	6-30-61	Plotted, cumulatively.
	Snowpack	Mt. Rose snow sampler	Daily, 0800 Winter season	10-31-56	6-30-61	Plotted on graph.
	Air Temperature					
	Max. & Min.	Thermometers	Daily, 0800	10-1-56	6-30-61	Plotted on graph.
	Max. & Min.	Thermograph	Continuous	11-9-56	6-30-61	Not tabulated.
	Current	Thermometers	Daily, 0800	10-1-56	6-30-61	Not tabulated.
		Thermograph	Continuous	11-9-56	6-30-61	Not tabulated.
	Air Moisture	Psychrometer	Daily, 0800	10-1-56	6-30-61	Not tabulated.
	Air Moisture	Hygrograph	Continuous	11-9-56	6-30-61	Air moisture at time of max. temp. plotted on graph.
	Atmospheric Pressure	Merc. Barometer	Weekly	1-24-57	6-30-61	Not tabulated.
	Atmospheric Pressure	Barograph	Continuous	2-1-57	6-30-61	Not tabulated.

Table 2.--Continued

STATION	ELEMENT	INSTRUMENT	FREQUENCY OF READINGS	PERIOD COVERED FROM	PERIOD COVERED TO	PROCESSING STATUS
M Upper Meadow Castle Creek	Precipitation	Recording gage	Continuous	4-19-58	6-30-61	Not tabulated.
	Snowfall	Snow Board	Bi-weekly, Winter season	10-31-56	6-30-61	Not tabulated.
	Snowpack	Mt. Rose snow sampler	Bi-weekly, Winter season	10-31-56	6-30-61	Tabulated, State reports.
	Air Temperature					
	Max. & Min.	Thermometers	Bi-weekly	12-26-56	6-30-60	Not tabulated.
	Max. & Min.	Thermograph	Continuous	12-26-56	1-4-60	Not tabulated.
	Air Moisture	Hygrograph	Continuous	12-26-56	1-4-60	Not tabulated.
O Onion Creek	Precipitation	Recording gage	Continuous	10-10-57	6-30-61	Not tabulated.
	Snowfall	Snow Board	Bi-weekly, Winter season	1-10-57	6-30-61	Not tabulated.
	Snowpack	Mt. Rose snow sampler	Bi-weekly, Winter season	1-10-57	6-30-61	Tabulated, State reports.
	Air Temperature					
	Max. & Min.	Thermometers	Bi-weekly	1-10-57	6-30-61	Not tabulated.
	Max. & Min.	Thermograph	Continuous	4-16-58	6-30-61	Not tabulated.
	Current	Thermograph	Continuous	4-16-58	6-30-61	Not tabulated.
	Air Moisture	Hygrograph	Continuous	4-16-58	6-30-61	Not tabulated.
	Soil Moisture	Nuclear Probe and Scaler	Monthly, Summer season	8-7-58	6-30-61	Reported.

Table 2.--Continued

STATION	ELEMENT	INSTRUMENT	FREQUENCY OF READINGS	PERIOD COVERED FROM	PERIOD COVERED TO	PROCESSING STATUS
R Ridge	Snowfall	Snow Board	Monthly, Winter season	2-20-57	6-30-61	Not tabulated.
	Snowpack	Mt. Rose snow sampler	Monthly, Winter season	2-20-57	6-30-61	Not tabulated.
Blue Canyon	Precipitation	Recording gage (from W. B.)	Continuous	9-1-58	6-30-61)	Hourly tabulation made by W. B. Combined into monthly summary.
	Wind Speed and Direction	Esterline-Angus Recorder	Continuous	9-1-58	6-30-61)	
Wishon Dam	Air Temperature					
	Max. & Min.	Thermometers	Daily, 0745	12-5-56	6-30-61)	Checked and scatter diagrams made comparing Wishon Dam with Big Creek PH #1 Grant Grove and Huntington Lake.
	Max. & Min.	Thermograph	Continuous	12-19-57	6-30-61)	
	Current	Thermometers	Daily, 0745	12-5-56	6-30-61)	
	Current	Thermograph	Continuous	12-19-57	6-30-61)	
	Air Moisture	Psychrometer	Daily, 0745	12-5-56	6-30-61)	
	Air Moisture	Hygrograph	Continuous	12-19-57	6-30-61	Not tabulated.
	Wind Miles	Anemometer	Daily, 0745	12-5-56	6-30-61	Not tabulated.
	Snow Evaporation	Snow Pans	Monthly, Winter season (Measured in Nov. & Dec., 1960.)	1-24-57	6-30-61	Tabulated and summarized.

Table 2.--Continued

STATION	ELEMENT	INSTRUMENT	FREQUENCY OF READINGS	PERIOD COVERED		PROCESSING STATUS
				FROM	TO	
Swain Mt.	Snowpack	Mt. Rose snow sampler	Monthly, Winter season	1-6-58	6-30-61	Reported.
	Soil Moisture Data	Nuclear Probe and Scaler	Monthly, Summer season	7-2-58	6-30-61	Reported.
Sagehen	Snowpack	Mt. Rose snow sampler	Monthly, Winter season	3-2-60	6-30-61	Summarized.
	Soil Moisture	Nuclear Probe and Scaler	Monthly, Summer season	7-24-58	6-30-61	Reported.
Salmon Creek	Precipitation	Storage gage	Bi-monthly	12-1-60	6-30-61	Tabulated.
Yuba Pass	Snowpack	Mt. Rose snow sampler	Monthly, Winter season	1-27-61	6-30-61	Summarized.
	Soil Moisture Data	Nuclear Probe and Scaler	Monthly, Summer season	10-28-60	6-30-61	Summarized.
Donner Ridge	Snowpack	Mt. Rose snow sampler	Monthly, Winter season	2-23-61	6-30-61	Tabulated.

Table 3.--Central Sierra Snow Laboratory daily precipitation data 1959-60

Date	1959 July	Aug.	Sept.	Oct.	Nov.	Dec.	1960 Jan.	Feb.	Mar.	Apr.	May	June
1								.15		.08		
2								1.99	.04		.25	T
3					T		.03		.06		.05	
4								.91	.41		.37	T
5								.49	.93			
6								.14	.88			
7								.55	2.14	.39	.05	
8							1.40	*	1.20	.01		
9				.10			1.35	7.42				
10				.01			1.50	1.94				
11							.63	.11		.06		
12							1.57		.76	.11		
13						.50		.10	1.96			
14						.02	.36			.14		
15			.27				.30					
16												
17												
18			.90				.03	.45				
19			1.67					.52		.23		
20			.11								.01	
21											.36	
22							.99			.34		
23							.20			.25	T	
24						.75				.59	1.36	
25		.12				2.05	1.56				.30	
26						.08	1.72	.02		.01	.06	
27							.42		.21	.99		
28							.36	.01	1.89	.29		
29									.03			
30							.25		.19	T		
31						.04			1.20			
Sums	0.0	0.12	2.95	0.11	T	3.44	12.67	14.80	11.90	3.49	2.81	T

Total for Year -- 52.29

* Amount included in following measurement, time distribution unknown.

Table 3a--Central Sierra Snow Laboratory daily precipitation data 1960-61

Date	1960: July	Aug.	Sept.	Oct.	Nov.	Dec.	1961: Jan.	Feb.	Mar.	Apr.	May	June
1						.16		.78				.78
2						2.38		.11	.31		.26	.64
3			.01		.07	.15		.62	.40			
4					.28				.06			
5	.02				*				.09			
6				.45	*				1.43		.52	
7				.52	.87			.05	.47		.38	
8	T				.03			.16				
9					.02		.06	.52	.60			
10			.04	.02			.03	1.12	.06	.02	.81	
11				.34		.04		.34	.49		*	
12					1.81			1.61	.11		1.27	
13					1.67			.02		.89		
14					2.62			.08				
15					.53	.01			.87			
16					.05	.12		.52	.18			
17						.92			1.03			
18					.94	.11		.04	.07	.08		
19					.10	.03					.09	
20									.52			
21					.05							
22										1.72		
23									.50	1.67		
24									.31	.18		
25								.73	1.35			
26				.02	1.76		.33		.53		.07	
27				.13	.38		.40	.02	.84			
28							.03		.35			
29	T											
30							.68					
31							.80				.43	
Sums	0.02	0.0	0.05	1.48	11.18	3.92	2.33	6.72	10.57	4.56	3.83	1.42

Total for Year -- 46.08

* Amount included in following measurement, time distribution unknown.

Table 4.--Monthly climatic summary, Central Sierra Snow Laboratory, 1960-61

Month	AIR TEMPERATURES							Total precipitation	Cum. Daily Snow w.e.	Month-end Snow w.e.[1]
	Averages			Extremes						
	Max.	Min.	Mean	Highest	Date	Lowest	Date			
1960	F°	F°	F°	F°		F°		inches	inches	inches
July	78.4	45.5	62.0	89	19	35	11	0.02	0.00	0.0
Aug.	76.8	40.6	58.7	86	10,12,19	29	23	0.00	0.00	0.0
Sept.	73.2	39.3	56.2	81	9	35	16,23,28	0.05	0.00	0.0
Oct.	57.3	31.9	44.6	72	3,4	23	12	1.48	0.30	0.0
Nov.	39.4	22.5	31.0	61	1,2	10	28,29	11.18	10.85	10.5
Dec.	38.2	17.5	27.8	51	24	5	4	3.92	3.54	12.8
1961										
Jan.	42.7	19.2	31.0	52	16,17,18	5	2	2.33	3.20	13.2
Feb.	38.7	20.1	29.4	53	21	6	26	6.72	5.47	17.8
Mar.	37.6	19.2	28.4	52	22	2	7	10.57	11.10	27.5
Apr.	47.7	24.2	36.0	66	3	9	24	4.56	4.57	13.5
May	51.1	28.7	39.9	64	19,25	16	7	3.83	2.73	0.0
June	72.0	41.1	56.6	86	15,16,21,22	30	9	1.42	0.00	0.0
Total								46.08	41.76	
Average	54.4	29.2	41.8							

1/ Water equivalent.

Table 5.--Snow accumulation at maximum pack on different slope and forest conditions, 7,000 feet elevation, Central Sierra Snow Laboratory, April 1, 1960

	North 315°-45°		East 45°-135°			South 135°-225°			West 225°-315°		
	Slope		Slope			Slope			Slope		
Forest:	15%	30%	15%	30%	60%	15%	30%	60%	15%	30%	Level
Opening[1/] 1/2H-1H[2/]	(29.6) 32-73-M (24.2) B-74-M	(32.8) D-76-L (22.8) 22-62-L	(22.6) 8-76-L	(21.3) 18-67-M		(25.4) A-74-M (20.6) 29-73-M	(21.0) 5-77-L		(29.6) 6-74-L	(22.9) C-76-L (28.4) 2-75-L	(27.8) 31-62-L
Opening 1H-2H	(34.6) 30-73-M (26.8) 25-61-L	(39.0) 16-72-M (37.4) 11-74-M	(35.1) 26-78-L	(32.8) 15-73-S		(29.4) 27-75-S	(17.7) 24-67-S		(32.2) 17-73-M	(27.4) 20-63-M	(32.6) 3-75-L
Opening 2H-4H			3/ (27.4) 7-76-L (31.1) 28-75-M				(26.6) 14-72-M		(36.4) 9-74-S		(25.1) 19-72-S
Opening >4H Av.		(39.8) 12-76-S		(28.8) 4-75-L		(29.8) 1-69-L			(29.7) 23-62-L		(36.2) 10-72-M
Density 20-50%	(40.4) 7-73-M	(31.5) 5-72-M (35.4) 14-75-M	(33.7) 16-75-S	(29.8) 19-77-L	(36.5) 1-74-L	(36.0) A-70-M (25.9) 29-66-L	(23.0) 13-75-L		(30.5) 11-74-S	(19.6) 10-73-M (24.7) 22-70-M	(28.4) 17-75-M
Density 50-80%	(26.3) 6-74-M (19.6) 32-60-L	(23.6) 31-69-L	(20.9) 2-76-L	(24.0) 23-70-M	(26.5) 4-75-L	(24.6) B-70-M (23.2) 15-75-M	(23.0) 8-76-L		(26.4) 12-74-M	(23.1) 18-73-M	(23.2) 3-75-L
Density 80-100%	(26.5) 30-69-S	(16.5) 26-66-M	(24.4) 24-67-M	(20.9) 25-67-M		(20.9) 9-77-L	(19.8) 20-78-M	(21.9) 21-76-L	(16.7) 28-67-L		(18.7) 27-67-L

1/ Numbers in parentheses are average snow water considering 50-50 forest and open in the "opening courses" and course average in the "density courses".

2/ Snow course number, elevation in 100's of feet and tree size: L=Large, over 100 feet high, M=Medium, 60-100 feet high, and S=Small, less than 60 feet high. Location and detailed description of each course given in Table 9.

3/ Course, Opening No. 7, has been misclassed in previous reports as a north slope; several elevations revised in this report.

Table 5a.--Snow accumulation at maximum pack on different slope and forest conditions, 7,000 feet elevation, Central Sierra Snow Laboratory, late March and early April, 1961

Forest	North 315°-45° Slope 15%	North 315°-45° Slope 30%	East 45°-135° Slope 15%	East 45°-135° Slope 30%	East 45°-135° Slope 60%	South 135°-225° Slope 15%	South 135°-225° Slope 30%	West 225°-315° Slope 15%	West 225°-315° Slope 30%	Level
Opening 1/2H-1H	1/ 2/ (18.6) B-74-M	(20.5) D-76-L (15.0) 22-62-L	3/ (13.8) 8-76-L	(19.0) 18-67-M		(16.4) A-74-M	(10.0) 5-77-L	(16.2) 6-74-L	(12.4) C-76-L (17.0) 2-75-L	(20.8) 31-62-L
Opening 1H-2H	3/ (24.6) 30-73-M (18.8) 25-61-L	(25.9) 16-72-M				3/ (18.0) 27-75-S				
Opening 2H-4H			3/ (22.0) 28-75-M							
Density 20-50%		(20.7) 5-72-M (17.5) 14-75-M			(25.9) 1-74-L	(20.7) A-70-M			(10.6) 10-73-M	
Density 50-80%					(15.4) 4-75-L	(12.9) B-70-M (15.2) 15-75-M			(11.7) 18-73-M	(14.8) 3-75-L
Density 80-100%	(12.8) 33-62-M									

1/ Numbers in parentheses are average snow water considering 50-50 forest and open in the "opening courses" and course average in the "density courses".

2/ Snow course number, elevation in 100's of feet and tree size: L=Large, over 100 feet high, M=Medium, 60-100 feet high, and S=Small, less than 60 feet high. Location and detailed description of each course given in Table 9.

3/ Has paper barriers.

Table 6.--Snow evaporation, Central Sierra Snow Laboratory, 1958-60

Month	1958		1959		1960	
	Forest	Opening	Forest	Opening	Forest	Opening
	- - - - - - - - - - - -	- - - - -	Inches of Water	- - - - -	- - - - - - - - - - - -	
January	1/ 0.032	1/ 0.136	0.057	0.218	0.004	0.054
February	0.017	0.089	0.009	0.185	0.138	0.269
March	0.048	0.184	2/ -0.509	0.793	0.182	0.375
April	0.358	0.495	0.352	0.409	0.131	0.276
May	2/ -0.028	0.118	0.022	0.079	0.083	0.167
June	-0.052	-0.030	3/	3/	4/	4/
Total	0.375	0.992	0.949	1.684	0.538	1.141

1/ Average of 1959 and 1960 data.

2/ Minus indicates condensation.

3/ All snow gone by May 14, 1959.

4/ All snow gone by May 18, 1960.

Table 7.--Snow evaporation, Wishon, Kings River Basin, 1958-60[1]

Year	Average daily evaporation from snow--inches: Jan.	Feb.	Mar.	Apr.	May	Total Evap. Jan.-May [2] Inches
			Within Forest			
1958	[3] -.012	-.004	.005	.005	-.008	
1959	.004	-	.005	-	-	
1960	-	.010	.006	.004	-	
Av.	-.004	.003	.005	.004	-.008	0
			In Openings in Forest			
1958	[2] .006	.002	.011	.006	-.008	
1959	.004	-	.006	-	-	
1960	.000	.012	.006	.003	.003	
Av.	.003	.007	.008	.004	-.002	0.49
			In Large Open Area			
1958	[2] .010	.016	.056	.005	.004	
1959	.004	-	.018	-	-	
1960	.004	.051	.006	-	-	
Av.	.006	.034	.026	.005	.004	1.85

1/ The snow evaporation data were taken by the PG&E Co. as part of their cooperation in the study.

2/ Total January through May evaporation for average of 123 clear weather days; stormy-day evaporation taken as zero.

3/ January 1957 data.

Table 8.--Soil moisture depths and estimated summer soil moisture deficits and summer water losses, Central Sierra Nevada, 6,000-7,600 feet, 1959

Soil Depth	Percent of Samples	Soil Moisture Loss Jun.-Sep.	Soil Moisture Loss Oct.-Nov.	Total Summer Loss[1/]
feet		inches	inches	inches
0-1	4	0.9	0.1	3.0
1-2	15	2.8	0.2	6.0
2-3	31	4.7	0.3	8.0
3-4	21	6.6	0.4	10.0
4-5	11	8.5	0.5	12.0
5-6	5	9.9	0.8	13.7
6-7	4	10.2	1.2	15.4
7-8	3	12.0	1.5	16.5
8-9	4	12.7	1.9	17.6
> 9	2	13.4	2.3	18.7
Av. 3.54		6.27	0.52	[1/] 9.79

1/ Includes 3 inches of summer rainfall which was lost by interception and evapotranspiration mostly from surface 2 feet of soil. (2 inches for soils less than 1 foot deep.)

Table 9.--Snow course characteristics (abbreviations listed at end of table)

Course No.		Location	Elev.	Slope	Azimuth	Vert. Curv.	Opening Size	Opening Type	Average Height of Trees	Forest Type	Remarks
			ft.	%					ft.		
Opening	1	Onion Creek	6940	18	170°	3	>4H	B	100	M. Con.	Several gullies
	2	Castle Creek	7470	25	245°	4	1/2-1H	Ro	110	YO-RF	Small trees invading
	3	Castle Creek	7500	Level	-	3	1-2H	Gr&Wi	115	YO-RF	Marshy in places
	4	Castle Creek	7540	23	53°	3	>4H	B&Gr	130	YO-RF	
	5	Castle Creek	7680	42	210°	2	1/2-1H	B	110	YO-RF	
	6	Castle Creek	7400	15	232°	2	1/2-1H	B	120	YO-RF	Small trees invading
	7	Castle Creek	7570	10	44°	4	2-4H	B&Gr	120	YO-RF	Gullies developing
	8	Castle Creek	7600	15	115°	5	1/2-1H	B	115	YO-RF	
	9	Castle Creek	7400	11	295°	3	2-4H	Ro	50	Y-RF	Some Y-LPP
	10	Castle Creek	7160	Level	-	1	>4H	Wi&Gr	70	Y-LPP-RF	Large meadow
	11	Castle Creek	7360	35	335°	4	1-2H	Ro	75	Y-RF	Some LPP
	12	Castle Creek	7620	26	0°	3	>4H	Ro	45	Y-LPP-RF	Ridge top
	14	Castle Creek	7240	34	177°	2	2-4H	B&Gr	65	YO-LPP	Some RF
	15	Castle Creek	7280	33	126°	3	1-2H	Br	40	Y-LPP	
	16	Castle Creek	7220	25	330°	3	1-2H	B	95	YO-RF-LPP	Logged 1958, slash
	17	Castle Creek	7260	18	250°	3	1-2H	B&Ro	70	YO-RF-LPP	Gullied, logged '58, slash
	18	Onion Creek	6700	25	93°	2	1/2-1H	B&Ro	90	SP-YP-F	
	19	Castle Creek	7160	Level	-	3	2-4H	Gr&Ro	55	YO-LPP	Wi, marshy in places
	20	Onion Creek	6320	27	298°	3	1-2H	Gr&Ro	80	WF-YP-IC	

Table 9.--Contd.

Course No.		Location	Elev.	Slope	Azimuth	Vert. Curv.	Opening Size	Opening Type	Average Height of Trees	Forest Type	Remarks
			ft.	%					ft.		
Opening	21	Onion Creek	6260	50	262°	2	1/2-1H	B&Ro	145	M. Con.	
	22	Grouse Ridge	6150	29	N	3	1/2-1H	B	115	YO-WF	Logged '59, slash
	23	Onion Creek	6200	17	308°	1	>4H	Gr&Ro	105	M. Con-Wi	
	24	Onion Creek	6740	33	148°	4	1-2H	Br	60	M. Con.	
	25	Grouse Ridge	6100	20	N	1	1-2H	B	100	YO-WF	Logged '59, slash
	26	Castle Creek	7760	19	111°	4	1-2H	B&Ro	105	RF-LPP	Small trees invading
	27	Castle Creek	7520	21	208°	5	1-2H	B	55	YO-RF-LPP	
	28	Castle Creek	7510	15	127°	5	2-4H	B	70	YO-RF-LPP	
	29	Castle Creek	7340	17	159°	5	1/2-1H	Ro	80	YO-RF-LPP	Logged '58, slash
	30	Castle Creek	7320	21	340°	2	1-2H	B&Gr	60	Y-RF-LPP	
	31	Onion Creek	6150	Level	-	1	1/2-1H	B	125	M. Con.	
	32	Onion Creek	7300	17	335°	4	1/2-1H	Br&Gr	95	YO-RF	
							Density Class				
							%				
Density	1	Castle Creek	7380	42	50°	3	20-50	-	110	OY-RF	Logged, slash
	2	Castle Creek	7600	17	110°	3	50-80	-	110	YO-RF	Fallen trees
	3	Castle Creek	7540	Level	-	5	50-80	-	110	OY-RF	
	4	Castle Creek	7520	40	60°	3	50-80	-	115	OY-RF	Fallen trees
	5	Castle Creek	7220	27	345°	3	50-80	-	80	Y-RF-LPP	Logged '58, slash

Table 9.--Contd.

Course No.		Location	Elev.	Slope	Azimuth	Vert. Curv.	Density Class	Opening Type	Average Height of Trees	Forest Type	Remarks
			ft.	%			%		ft.		
Density	6	Castle Creek	7380	19	346°	2	50-80	-	80	YO-RF-LPP	Logged '58, slash
	7	Castle Creek	7300	13	7°	4	20-50	-	65	Y-RF-LPP	Very open
	8	Castle Creek	7560	29	207°	3	50-80	-	105	YO-RF	Fallen trees
	9	Castle Creek	7720	15	208°	3	80-100	-	110	YO-RF	
	10	Castle Creek	7300	35	291°	2	50-80	-	80	YO-RF-LPP	Logged '58, slash
	11	Castle Creek	7380	13	280°	3	20-50	-	45	Y-RF-LPP	
	12	Castle Creek	7430	18	310°	3	50-80	-	60	Y-RF-LPP	
	13	Castle Creek	7460	26	205°	2	20-50	-	100	YO-RF	
	14	Castle Creek	7500	42	356°	3	20-50	-	70	OY-RF	
	15	Castle Creek	7515	7	195°	3	50-80	-	95	YO-LPP-RF	Logged '58, slash
	16	Castle Creek	7510	12	115°	5	20-50	-	50	YO-LPP-RF	Many gullies
	17	Castle Creek	7510	4	203°	5	20-50	-	65	YO-LPP	Some RF, logged '58, slash
	18	Castle Creek	7320	30	285°	4	50-80	-	90	YO-RF-LPP	
	19	Castle Creek	7720	33	82°	4	20-50	-	120	O-RF	Fallen trees
	20	Castle Creek	7750	31	210°	4	80-100	-	95	OY-RF	Fallen trees
	21	Castle Creek	7580	46	217°	2	80-100	-	105	OY-LPP-RF	Fallen trees
	22	Onion Creek	7000	32	262°	3	20-50	-	90	O-RF	Old logging, slash
	23	Onion Creek	6960	34	87°	3	50-80	-	100	O-RF-JP	Fallen trees
	24	Onion Creek	6730	11	85°	5	80-100	-	65	M. Con.	Fallen trees
	25	Onion Creek	6710	26	100°	3	80-100	-	75	M. Con.	Fallen trees

Table 9.--Contd.

Course No.	Location	Elev.	Slope	Azimuth	Vert. Curv.	Density Class	Opening Type	Average Height of Trees	Forest Type	Remarks
		ft.	%			%		ft.		
Density 26	Onion Creek	6600	41	37°	4	80-100	-	90	M. Con.	Fallen trees
27	Onion Creek	6660	3	80°	3	80-100	-	110	M. Con.	
28	Onion Creek	6660	12	245°	5	80-100	-	140	OY-WF	Fallen trees
29	Onion Creek	6660	7	187°	2	20-50	-	140	OY-RF	
30	Vic. Lake Van Norden	6910	20	26°	3	80-100	-	65	OY-RF	Fallen trees
31	Vic. Lake Van Norden	6910	26	28°	3	50-80	-	90	OY-RF	
32	Grouse Ridge	6050	20	N	2	50-80	-	100	YO-WF	
33	Grouse Ridge	6200	15	N	3	80-100	-	70	Y-WF	Dense small trees
						Opening Size				
Transect 1	Castle Creek	7200	Level	-	3	-	-	80	YO-RF-LPP	
2	Castle Creek	7200	10	SW	3	-	-	55	YO-LPP	
3	Castle Creek	7200	10	SW	3	-	-	95	YO-RF-LPP	
Station "H"	Castle Creek	6900	5	S	3	1/2-1H	Gr	50	LPP	
"O"	Onion Creek	6080	25	S	3	1/2-1H	B	95	WF-JP	
"M"	Castle Creek	7360	8	S	3	>4H	Gr	15	Wi-F-P	
120	Onion Creek	6100	5	SW	2	2-4H	Gr	95	WF-JP	
"R"	Onion Creek	7280	10	W	5	1-2H	Br	75	YO-F-P	

Table 9.--Contd.

Course No.	Location	Elev.	Slope	Azimuth	Vert. Curv.	Opening Size	Opening Type	Average Height of Trees	Forest Type	Remarks
		ft.	%					ft.		
Plot A	Castle Creek	7400	10	135°	4	1/2-1H	B	85	YO-RF-LPP	
Plot B	Castle Creek	7400	19	321°	3	1/2-1H	B	95	Y-RF-LPP	
Plot C	Castle Creek	7560	38	225°	3	1/2-1H	B	110	YO-RF	
Plot D	Castle Creek	7650	37	43°	3	1/2-1H	B	100	YO-RF	
Block A	Onion Creek	7000	10	S	3	-	For	-	OY-JP-RF	Logged '57
Block B	Onion Creek	7000	10	S	3	-	For	-	OY-JP-RF	Unlogged
Block C	Onion Creek	6800	10	S	5	-	Br	-	Br	Fir reproduction
Block D	Onion Creek	6800	15	SW	5	-	Br	-	Br	Fir reproduction
Block E	Onion Creek	6800	15	SE	4	-	Br	-	Br	Fir reproduction
Block J	Onion Creek	6800	10	S	5	-	For	-	YO-RF	
Transect 1	Van Norden Powerline	6850	15	0°	2	2H	-	100	YO-RF	
Transect 2	Van Norden Powerline	6850	30	315°	2	2H	-	100	YO-RF	
Transect 1	Yuba Pass	6800	15	SE	3	-	-	100	OY-RF	
Transect 2	Yuba Pass	6800	15	SE	3	-	-	100	OY-RF	
Area A	Swain Mt.	6100	15	NE	3	-	-	165	O-RF-WF	Logged '58
Areas C & D	Swain Mt.	6400	15	NE	3	-	-	165	OY-F-P	Logged '58 (C only)
Course 2	Swain Mt.	5900	5	E	3	-	-	120	YO-RF	

Table 9.--Contd.

Course No.	Location	Elev.	Slope	Azimuth	Vert. Curv.	Opening Size	Opening Type	Average Height of Trees	Forest Type	Remarks
		ft.	%					ft.		
Block F	Sagehen Creek	6900	12	135°	3	-	Cl	-	Br	Dozed, Fall '57; planted to P, 5/58
Block G	Sagehen Creek	6900	12	135°	3	-	Br	-	Br	
Block H	Sagehen Creek	6900	12	135°	3	-	Br	-	Br	
Block I	Sagehen Creek	6700	12	135°	3	-	For	80	JP-F	
Block V	Sagehen Creek	6900	12	135°	3	-	Br	-	Br	Beside dozed area
Block W	Sagehen Creek	6900	12	135°	3	-	Br	-	Br	Beside dozed area
Watershed 2	Sagehen Creek	7300	30	N	2	-	-	70	RF-LPP-JP	Unburned
4	Sagehen Creek	7000	20	S	2	-	-	70	Br-JP	Unburned
6	Sagehen Creek	6900	20	N	2	-	-	70	LPP	b, 8/60, sl
7	Sagehen Creek	6850	15	N	2	-	-	70	LPP	b, 8/60, sl, pw
9	Sagehen Creek	6500	15	N	2	-	-	70	LPP	b, 8/60, No treatment
12	Sagehen Creek	6450	20	N	1	-	-	-	Br	b, 8/60, ct
13	Sagehen Creek	6550	20	N	1	-	-	-	Br	b, 8/60, No treatment
14	Sagehen Creek	6550	20	S	2	-	-	70	Br-JP	b, 8/60, grs
15	Sagehen Creek	6500	15	S	2	-	-	70	Br-JP	b, grs
19	Prosser Creek	6800	35	S	2	-	-	-	Br	b, 8/60, ct
20	Prosser Creek	6550	25	S	2	-	-	70	JP-LPP	b, 8/60, sl
22	Prosser Creek	6550	20	S	2	-	-	70	JP-LPP	b, 8/60, No treatment
23	Prosser Creek	6450	25	W	2	-	-	70	JP-LPP	b, 8/60, sl, pw

Table 9.--Contd. -- Abbreviations

Vertical Curvature (6)	Opening Type	Remarks
1 = Highly concave (lower slope)	Gr = Grass	b = burned
2 = Moderately concave	Br = Brush	sl = salvage logged
3 = Neutral (level or mid-slope)	B = Bare	pw = pole windrowed
4 = Moderately convex	For = Forest	ct = contour terraced
5 = Highly convex (ridge)	Cl = Clear	grs = grass seeded
	Ro = Rocky	
	Wi = Willow	

Forest Type

O = Old growth

Y = Young growth

YO = Mixture of young and old trees with old trees forming 20 to 50 percent of cover.

OY = Mixture of old and young trees with young trees forming from 20 to 50 percent of cover.

F = Fir, RF = Red Fir, WF = White Fir.

P = Pine, LPP = Lodgepole Pine, YP = Yellow Pine, SP = Sugar Pine, JP = Jeffrey Pine.

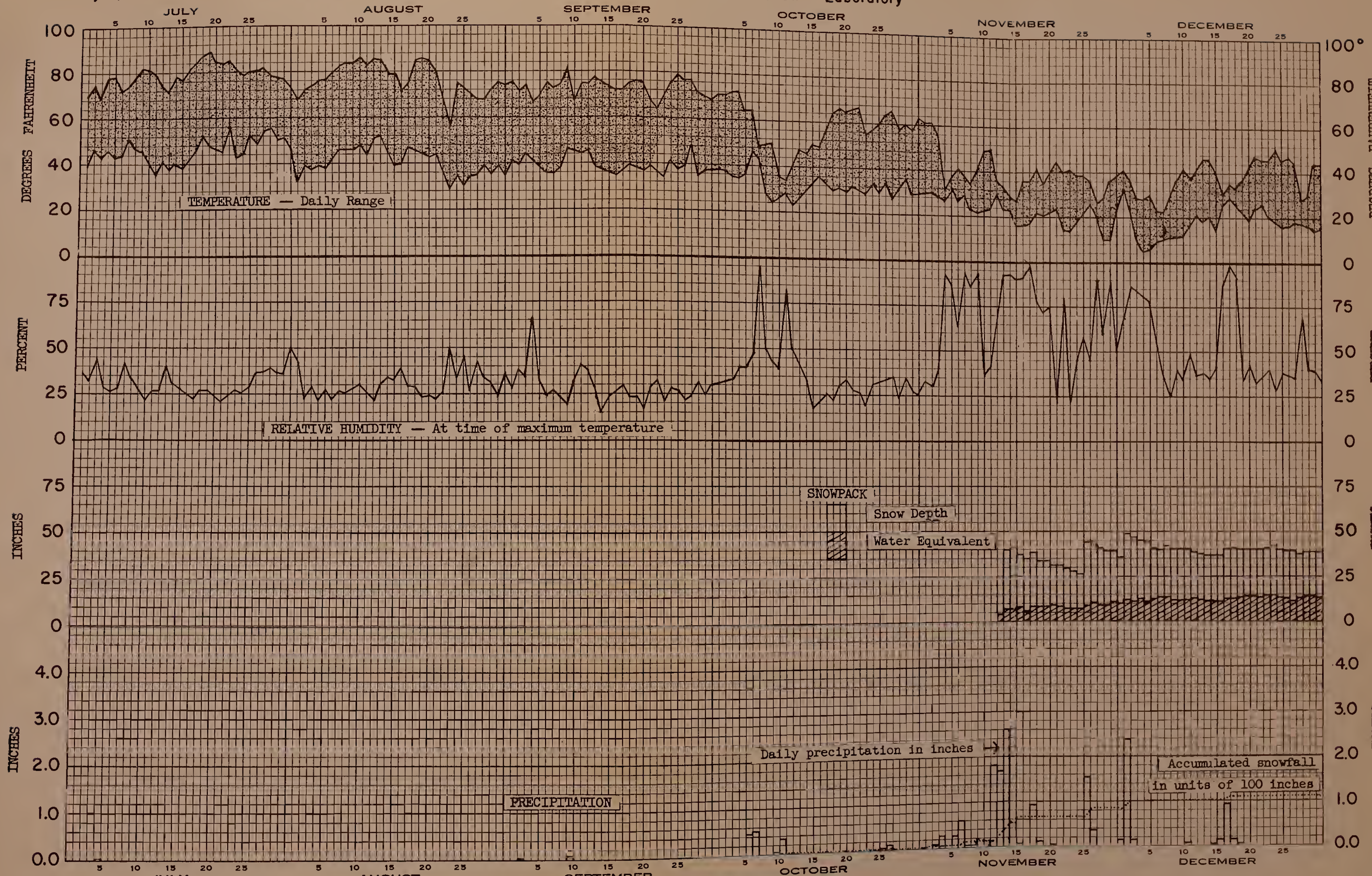
IC = Incense Cedar.

M. Con. = Mixed Conifer.

APPENDIX B

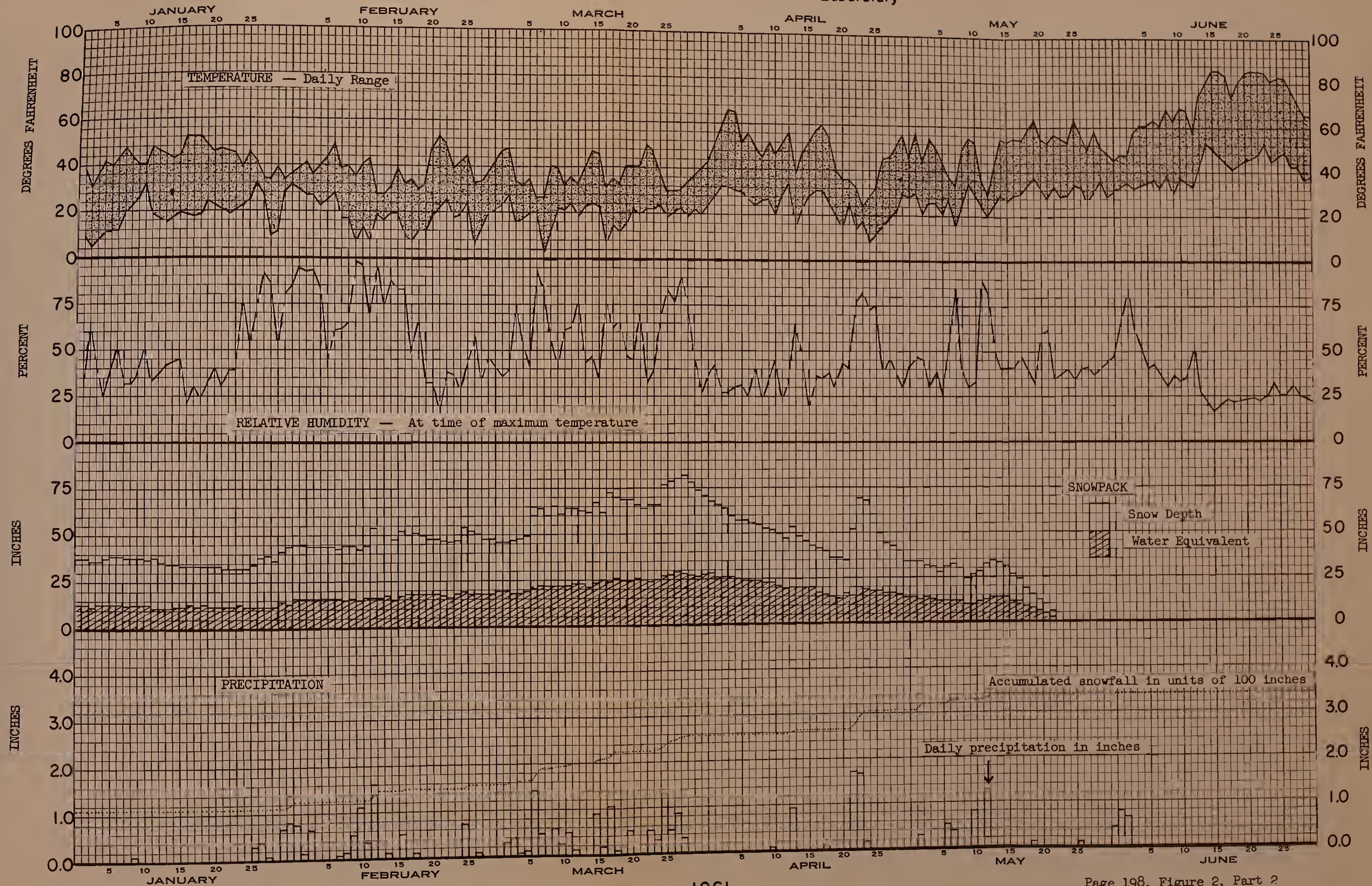
FIGURES 2-6

Synopsis of Hydrometeorological Elements - 1960 - 1961, Central Sierra Snow Laboratory

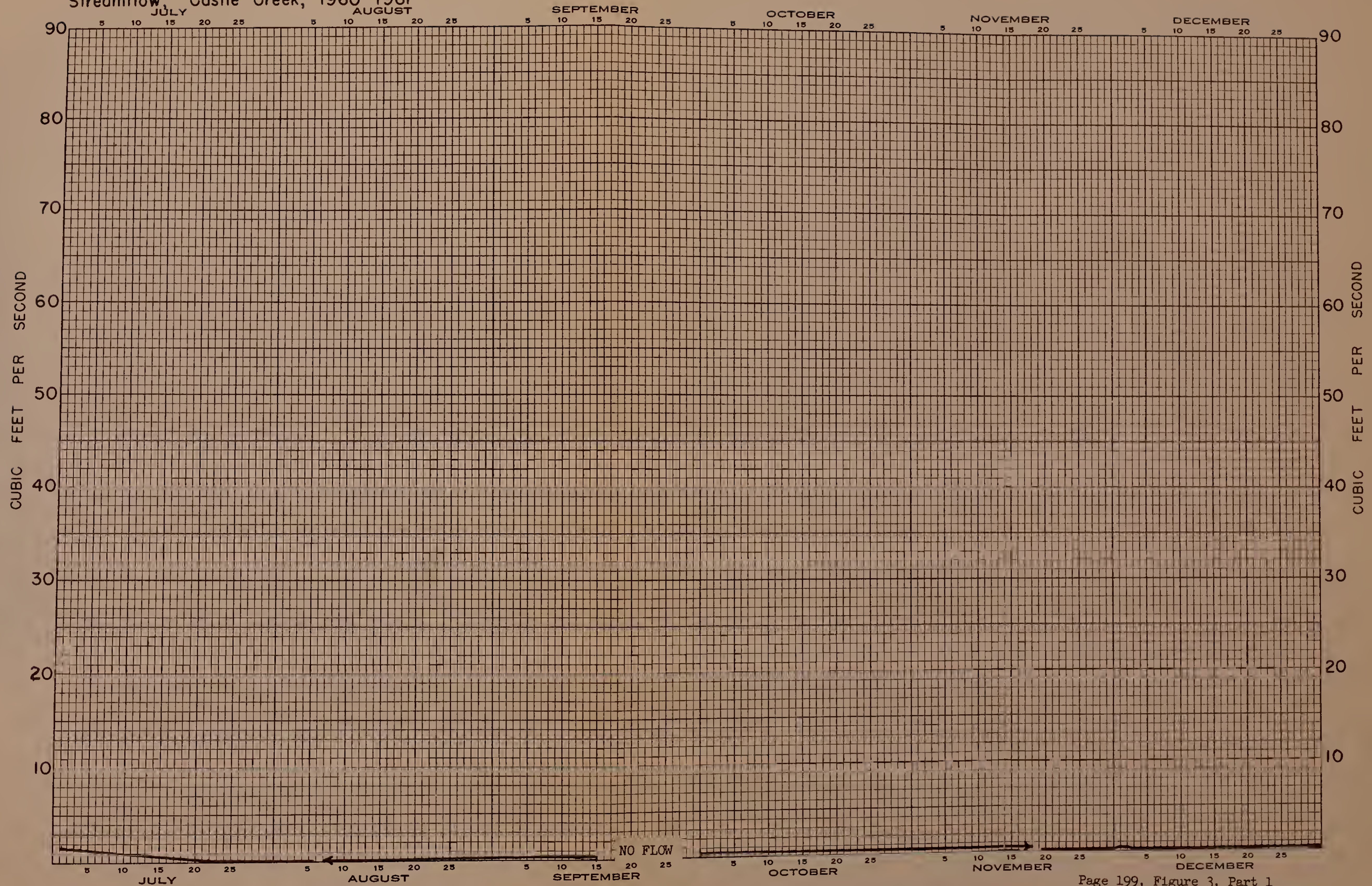


1960

Synopsis of Hydrometeorological Elements — 1960 - 1961, Central Sierra Snow Laboratory



Streamflow, Castle Creek, 1960-1961



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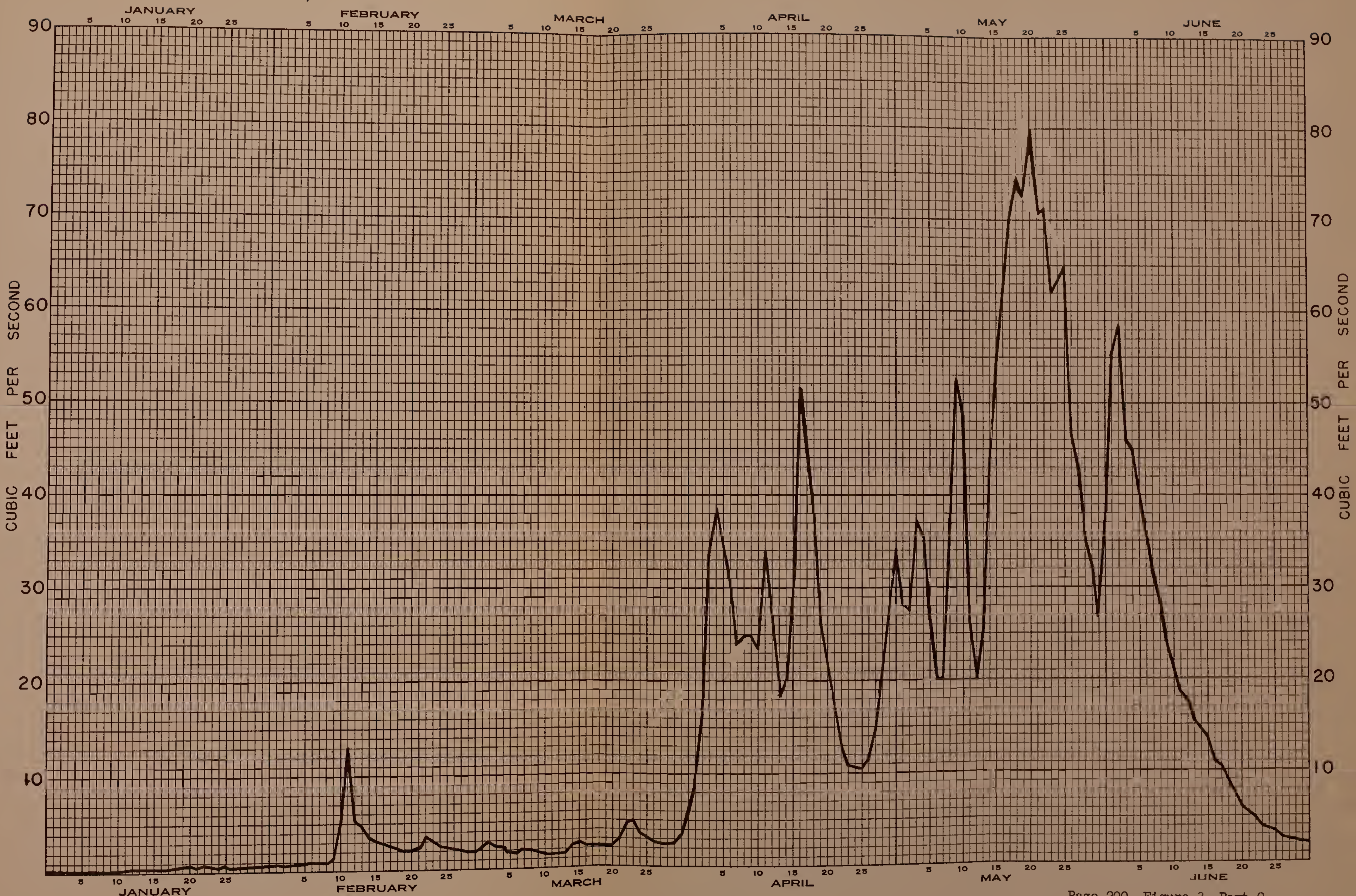
MEAN DAILY FLOW
1960

Streamflow, Castle Creek, 1960-1961



MEAN DAILY FLOW
1961

Page 200, Figure 3, Part 2

HYDROLOGIC STUDY SITES

CASTLE CREEK BASIN AREA

1957 - 1961

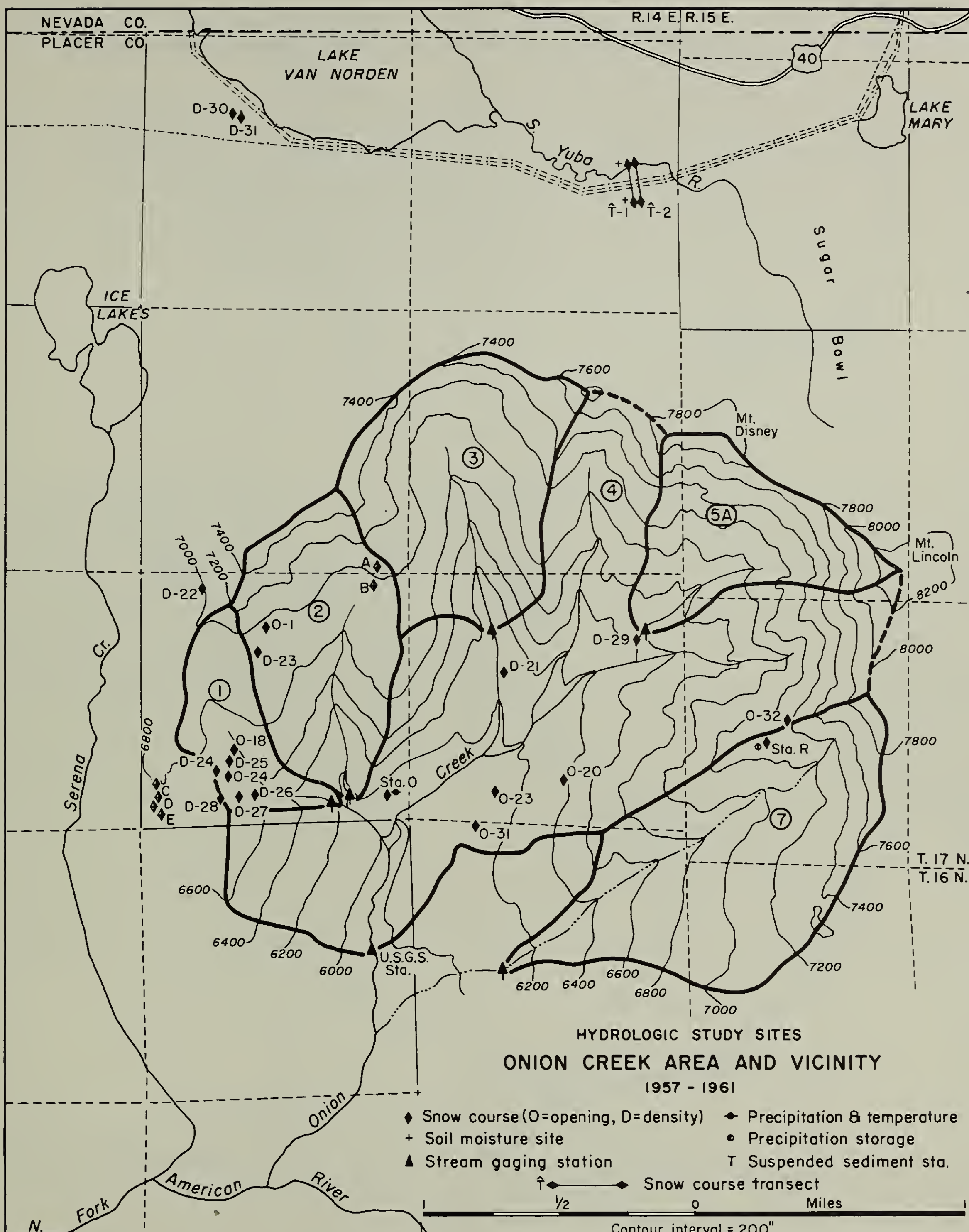
1 ½ 0 Miles 1

Contour interval = 200'

Watershed boundary

- ♦ Snow course (O=opening, D=density)
- \+ Soil moisture site
- ▲ Stream gaging station
- ⊗ Weather station, complete
- • Rain gage
- ᵀ Suspended sediment station
- T̂ ♦——♦ Snow course transect

Figure 4



HYDROLOGIC STUDY SITES
ONION CREEK AREA AND VICINITY
1957 - 1961
Snow course (O=opening, D=density)
Soil moisture site
Stream gaging station
Precipitation & temperature
Precipitation storage
Suspended sediment sta.
Snow course transect
Miles
Contour interval = 200"
NEVADA CO.
PLACER CO.
R.14 E. R.15 E.
LAKE VAN NORDEN
LAKE MARY
ICE LAKES
S. Yuba R.
Sugar Bowl
Mt. Disney
Mt. Lincoln
Serena Cr.
Onion Creek
U.S.G.S. Sta.
N. Fork American River
T. 17 N.
T. 16 N.

Figure 5

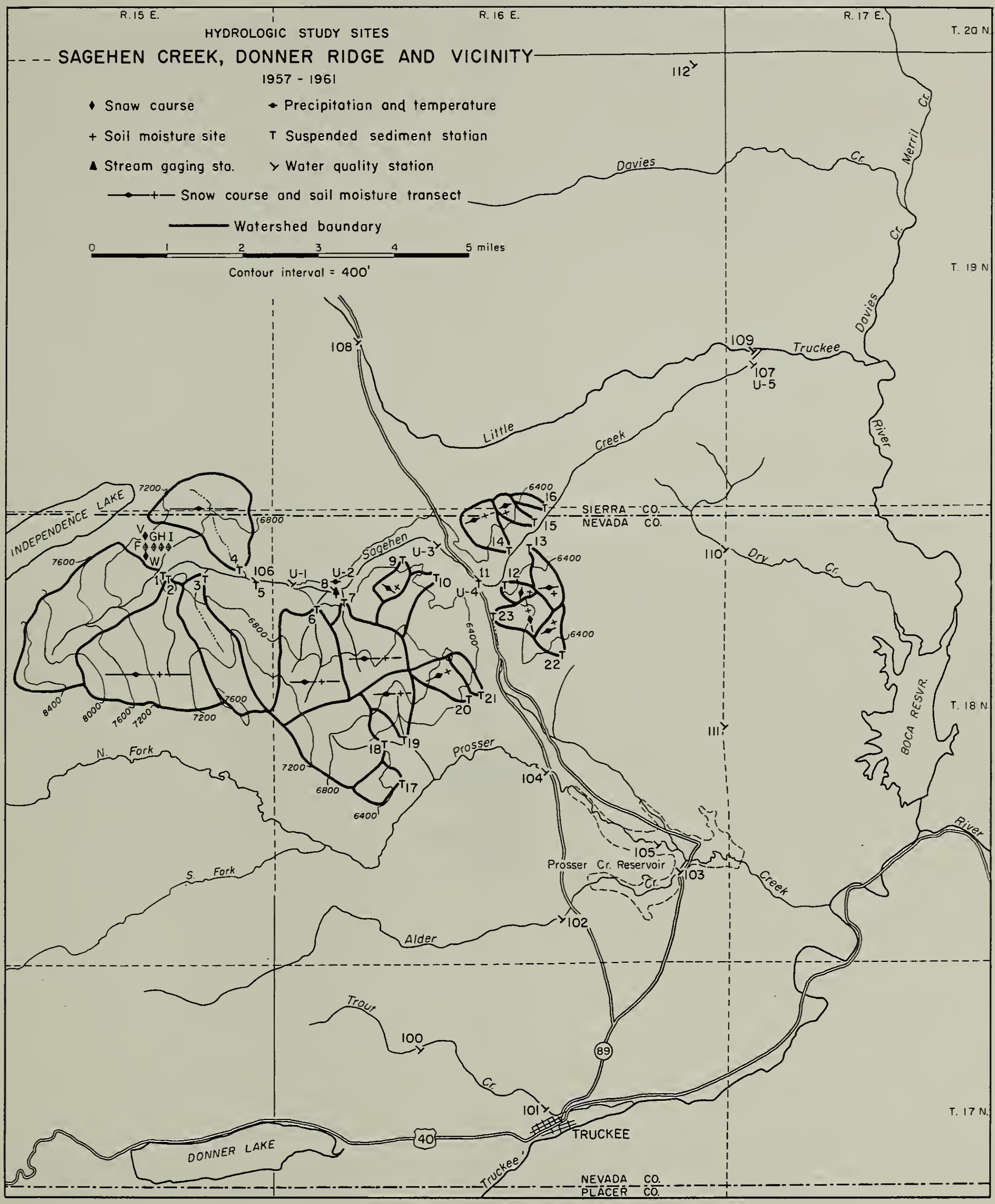

HYDROLOGIC STUDY SITES
SAGEHEN CREEK, DONNER RIDGE AND VICINITY
1957 - 1961
Snow course
Precipitation and temperature
Soil moisture site
Suspended sediment station
Stream gaging sta.
Water quality station
Snow course and soil moisture transect
Watershed boundary
Contour interval = 400'
R. 15 E.
R. 16 E.
R. 17 E.
T. 20 N.
T. 19 N.
T. 18 N.
T. 17 N.
SIERRA CO.
NEVADA CO.
PLACER CO.
INDEPENDENCE LAKE
DONNER LAKE
TRUCKEE
BOCA RESVR.
Prosser Cr. Reservoir

Figure 6

APPENDIX C

REPRINTS